Ontario Geological Survey
Aggregate Resources Inventory
Paper 72

Aggregate Resources Inventory of the Kapuskasing Area Cochrane District Northern Ontario

By Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1984

THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS THROUGH THE NORTHERN ONTARIO GEOLOGICAL SURVEY (NOGS) PROGRAM.

Ontario

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ISSN 0708-2061
ISBN 0-7743-6110-7

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The Lands Staff of Kapuaskasing District, and the Mineral Resources Staff of Northern Region of the Ministry of Natural Resources assisted in the collection of data, field checking and review of this report.

Parts of this publication may be quoted if credit is given to the Ontario Ministry of Natural Resources, Ontario Geological Survey. It is recommended that reference to this report be made in the following form:

Ontario Geological Survey
1984: Aggregate Resources Inventory of the Kapuskasing Area, Cochrane District; Ontario Geological Survey, Aggregate Resources Inventory Paper 72, 65 p., 6 tables, 6 maps, scale 1:50 000.

Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

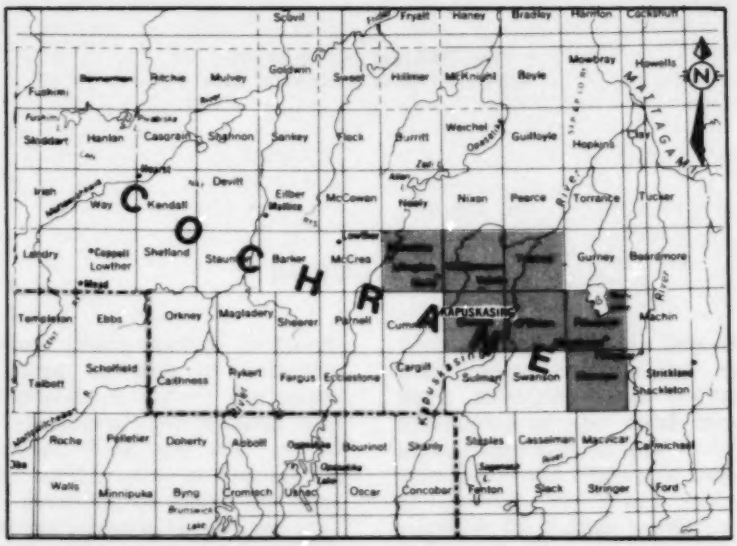

Figure 1 - Key Map Showing the Location of the Kapuskasing Area, Scale 1:1 584 000.

This report includes an inventory and evaluation of sand and gravel as well as bedrock resources, for seven townships in the Kapuskasing Area in the District of Cochrane. The report is based on data from previous field studies and on a detailed field assessment undertaken by a two-man field party funded by the Ontario Ministry of Northern Affairs.

A total of twelve sand and gravel deposits in the project area have been selected as resource areas of primary significance. These resource areas occupy a total of 4400 acres (1780 ha), of which 2700 acres (1090 ha) are presently available for extraction. Based on average thickness estimates for each resource area, the total sand and gravel resource tonnage is estimated to be 214 million tons (194 million tonnes).

In the townships to the east of the Kapuskasing River, large supplies of good quality crushable gravel are available in two esker systems. With proper resource management, these supplies should be sufficient for local use in the Kapuskasing Area for a considerable period of time. The townships west of the Kapuskasing River, however, have little crushable gravel remaining. Resources of bedrock-derived crushed stone may, therefore, become important in the future.

The Kapuskasing Area is mainly underlain by a migmatite-metasedimentary-metavolcanic complex and felsic intrusive rocks. These two bedrock groups, along with scattered diabase dikes, are suitable for the production of crushed aggregate. Eleven specific areas of these rock types, covered by less than 25 feet (8 m) of drift, have been selected for possible resource protection. These resource areas occupy a total of 54,000 acres (21 900 ha), of which 49,000 acres (19 800 ha) are available for extraction. Based on a standardized, quarriable thickness estimate of 60 feet (18 m), possible crushed stone resources are approximately 10,900 million tons (9900 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE KAPUSAKSING AREA[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1981, the total tonnage of mineral aggregates extracted was 121 million tons (110 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1982).

Although mineral aggregate deposits are plentiful in Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, March 8, 1983.
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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report involved the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References) as well as field examination of potential resource areas. Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas where information is limited.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11- to 45-kg) units either from existing pit faces or from backhoe test holes. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed in the laboratories of the Soils and Aggregates Section, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, 9- to 15-foot (3- to 5-m) sections were excavated, using a wheeled backhoe. The stratigraphic section in these test holes was described and bulk samples were taken to better assess the potential of the deposit. The symbols for and locations of sample and test hole sites are noted on Map 1.

In the office, the field data were supplemented by pit information on file with the Engineering Materials Office of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The locations of additional sources were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used in conjunction with other evidence. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3-m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per

cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 are calculated in the following way. Two successive subtractions are made from the total area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas that have previously been extracted. The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage presently available for extractive development and/or resource protection.

Reserve estimates are calculated for deposits of primary significance. Reserve estimates for deposits of secondary and tertiary significance are not calculated in Table 3, however the aggregate potential of these deposits is discussed in the report.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of bedrock formations overlain by less than 25 feet (8 m) of unconsolidated overburden is determined from bedrock geology maps and from the interpretation of available subsurface data. In some areas, drift thickness values were inferred from terrain units used in Engineering and Terrain Geology mapping of parts of northern Ontario. The measured extent of such areas is then multiplied by the estimated quarriable thickness of the rock unit. In most cases a standardized estimate of a quarriable thickness of 60 feet (18 m) is used. Although the thicknesses of the Precambrian bedrock units in northern Ontario are all probably considerably greater, the 60-foot (18-m) value is considered an appropriate estimate of the maximum thickness of material that can be economically and technologically extracted from a given quarry face. Volume estimates are then multiplied by 3700, which is the estimated weight, in Imperial tons, of a one-foot (0.3-m) thick section of Precambrian granitic rock one acre (0.4 ha) in extent, assuming a bulk density of 170 pounds per cubic foot (2729 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregate are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p.7) and with the Association of Professional Engineers of Ontario (1976) (see Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

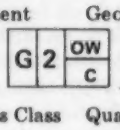
For each map area there are three maps, each portraying a different aspect of the aggregate resources in the report area. Maps 1A and 1B, "Distribution of Sand and Gravel Deposits", give a comprehensive inventory of the sand and gravel resources in the report area. Maps 2A and 2B, "Selected Sand and Gravel Resource Areas", show those deposits which are considered to represent the largest and/or highest quality resources in the area. Maps 3A and 3B, "Bedrock Resources", show the distribution of bedrock formations, the distribution of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAPS 1A and 1B: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Maps 1A and 1B are derived directly from existing surficial geology maps or from airphoto interpretation in areas where mapping is incomplete. The maps represent a comprehensive inventory of all sand and gravel deposits within the study area and serve as a base for the calculation of total sand and gravel resources. All known deposits are delineated by a dashed line and given a brown or beige tone. The present level of extractive activity is also indicated. The maps represent a summary of all available information related to the quantity and quality of aggregate in the mapped deposits. Much of this information is contained in two symbols which appear on the maps. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for every deposit shown on Maps 1A and 1B. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Maps 1A and 1B.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identifies the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identifies the main quality limitations that may be present in the deposit as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, and silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand and 10 percent silt and clay:

Test hole locations are shown on Maps 1A and 1B by a solid drill hole symbol. All known sand and gravel pits, whether presently active or inactive, are shown by a dot symbol and a number which refers to the pit descriptions given in Table 2. Each description notes the location and owner of the pit and the estimated face height and gravel content.

MAPS 2A and 2B: SELECTED SAND AND GRAVEL RESOURCE AREAS

Maps 2A and 2B are interpretative maps derived from an evaluation of the deposits shown on Maps 1A and 1B. The deposits identified on Maps 2A and 2B are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary, secondary, and tertiary. These areas are identified on Maps 2A and 2B by different shading patterns.

Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number. All such deposits are shown by a red tone on Maps 2A and 2B.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light red tone on the maps. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered as an important part of the aggregate supply of the municipality.

Areas of tertiary significance are outlined on the map by a solid line but have no tone. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the report area is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6 m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Maps 1A and 1B. They are: gravel content (G or S), fines (C), oversize (O) and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content, (G or S), indicates the suitability of aggregate for various

uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm seive are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphalt aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high quality uses such as concrete and asphalt. Similarly, highly weathered, very porous and friable rock can restrict the quality of an aggregate. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations.

Analyses of unprocessed samples obtained from test holes and pits have been plotted on grain size distribution graphs. These figures are divided into either coarse or fine aggregate graphs. The coarse aggregate graphs show samples with greater than 35 percent gravel, while the fine aggregate graphs show samples with less than 35 percent gravel. Also on the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products: Granular Base Course A, B, and C. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, powerlines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report, but readers are encouraged to discuss them with personnel of the pertinent District Office of the

Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain roughly at the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAPS 3A AND 3B BEDROCK RESOURCES

Maps 3A and 3B are interpretative maps derived from bedrock geology maps, water well data from the Ontario Ministry of the Environment, drilling assessment data from the Ontario Ministry of Natural Resources and from the Northern Ontario Engineering Geology Terrain Studies produced for the Ontario Geological Survey. Maps 3A and 3B are based on concepts similar to those outlined for the previous maps, but display both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Drift-covered bedrock is indicated by two blue tones and is delineated by drift thickness contour lines. The delineation of these areas has been inferred primarily from terrain units identified on Data Base Maps of the Northern Ontario Engineering Geology Terrain Studies, which exist for much of northern Ontario.

Areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface are indicated by dark blue tone. Isolated bedrock outcrops which lie outside these areas are indicated by a black "X" symbol. These areas constitute potential resource areas of primary significance, because of their easy access. Areas where the bedrock is covered by 3 to 25 feet (1 to 8 m) of drift are indicated by medium blue tone. Quarrying is possible in this depth of overburden and these also represent potential resource areas. Outside the delineated areas of thin drift cover, the bedrock can be assumed to be overlain by more than 25 feet (8 m) of drift. These areas constitute resources which have extractive value only in specific circumstances and it is unlikely these areas will constitute resource areas of economic significance.

Scattered bedrock outcrops and areas of thin drift may occur in all the areas, but may not be shown on the maps due to the scale of the original mapping.

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the report area. All known quarries are shown by a dot symbol and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and an estimate of face height. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and Communications. The main characteristics of the bedrock units found in the study area are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations. Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of bedrock resource areas has been restricted to a single level of significance. Two factors support this approach: (1) the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material and (2) crushed bedrock has a higher unit value than sand and gravel, therefore longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The wide range of possible resource areas allows greater flexibility in locating quarry operations away from areas of intense land use competition. The selected areas are shown on Maps 3A and 3B by a line pattern and the calculated available tonnages are given in Table 6.

It should be stressed that the Precambrian Shield rocks in northern Ontario are generally more complex and variable than the Paleozoic rocks of southern Ontario. They often show wide variations in mineralogy, texture (grain size) and degree of weathering, even within specific rock types and over relatively short distances. As these factors are considered important in determining the suitability of the bedrock for use as aggregate, the aggregate potential may also vary considerably from location to location.

Careful selection is especially important if the bedrock is to be used as concrete aggregate. Deleterious chemical reactions may develop in the concrete which can lead to its eventual deterioration. Fortunately, these chemical reactions should not influence the use of bedrock-derived aggregate for hot-laid asphaltic and road base material. However, highly weathered, very porous and friable rock should be avoided for all uses.

For these reasons, the total area selected as a bedrock resource should not be considered acceptable for aggregate use. They are, however, areas in which the probability of finding a supply of acceptable aggregate is considered most likely.

Selected Bedrock Resource Areas are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE KAPUSKASING AREA

LOCATION AND POPULATION

The Kapuskasing Area includes seven townships surrounding the Town of Kapuskasing. These are O'Brien, Teetzel, Nansen, Fauquier, Owens, Williamson, and Idington Townships. The study area is located on portions of the Wakusimi River (42 G/1), Lost River (42 G/7), Kapuskasing (42 G/8), Pearce Lake (42 G/9), and Opasatika (42 G/10) map sheets of the National Topographic System at a scale of 1:50 000.

O'Brien Township (Maps 1A, 2A, and 3A) occupies 51,840 acres (20 980 ha). The total population of O'Brien Township was 12 582 in 1975 and figures since then suggest that population growth has remained relatively stable (Ontario Ministry of Intergovernmental Affairs, personal communication, 1981; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1976). Most of the township's population in 1976 was located in the Town of Kapuskasing. Kapuskasing, a major forestry-based retail and industrial centre, is located at the junction of the Kapuskasing River and King's Highway 11.

The three remaining townships on Maps 1A, 2A, and 3A are Teetzel, Nansen, and Fauquier. They cover an area of approximately 156,000 acres (63 000 ha). The population of Fauquier Township was 1449 in 1980, with the majority of the people centred around the community of Moonbeam (Ontario Ministry of Intergovernmental Affairs 1981). At the time of writing, there were no permanent residents in Nansen and Teetzel Townships.

The townships of Owens, Williamson, and Idington (Maps 1B, 2B, and 3B) occupy an area of 124,286 acres (50 298 ha). Population figures for these three townships showed an increase of about 5 percent from 1326 in 1975 to 1396 in 1980 (Ontario Ministry of Intergovernmental Affairs 1981; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1976).

The entire Kapuskasing Area is serviced by both road and rail transport systems. King's Highway 11, which is the northern route for the Trans-Canada Highway, dissects the area in an approximate northwest-southeast direction. The majority of the remaining roads form a relatively extensive grid pattern around the Town of Kapuskasing. Other more remote roads are generally seasonal and mainly service the forest industry. Rail access is provided by the Canadian National Railways which runs parallel to King's Highway 11.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The Kapuskasing Area lies within the Abitibi Upland of the James Bay Region (Bostock 1970). The relief is generally low, but rises slowly from north to south away from the Hudson Bay Lowland. Drift cover over the bedrock surface is generally greater than 60 feet (18 m). However, bedrock outcrops are common. Consequently, many areas have irregular surface features.

During the Great Ice Age (Pleistocene Epoch), advances and retreats of massive continental ice sheets covered the project area. The fan-shaped ice mass moved in a south to southwesterly direction and deposited a compact, stony, silty sand till (Boissonneau 1966). Very little of this material is exposed in the Kapuskasing Area because of burial by younger glacial sediments. The older till material is usually unacceptable as a high specification aggregate resource because of the high fines content, but it can serve as a source of excellent borrow material.

As the glacier began melting back to the north, eskers were formed beneath the ice. These sinuous deposits contain the majority of the high grade sand and gravel resources in the Kapuskasing Area. Two large esker systems located in the eastern half of the area are important sources of good quality crushable gravel suitable for a wide range of road-building and construction materials. Eskers in the western half of the Kapuskasing Area tend to be smaller and contain lesser amounts of crushable gravel.

While the glacier's margin continued to retreat northwards, an ice-contact delta formed at the south end of Remi Lake in Fauquier Township. Here, the ice apparently remained stationary long enough for fine-grained deltaic sediments to be deposited. An esker branching off to the northeast from the main north-south trending

esker appears to have formed at the same time as the deltaic deposit. Both the deltaic and esker sediments are useful sources of aggregate.

As deglaciation continued, meltwaters formed glacial Lake Barlow-Ojibway. This lake covered much of northeastern Ontario including the Kapuskasing Area. Fine-grained glaciolacustrine sediments were deposited covering most of the previously deposited older material.

Approximately 8200 years ago, a cooling trend caused the continental glacier to readvance (Prest 1970; Vincent and Hardy 1979). This readvance overrode and incorporated the glaciolacustrine materials deposited in Lake Barlow-Ojibway, and as a result, a fine-grained silty clay till was deposited (Cochrane till).

This readvance occurred in two stages. During the early phase, ice advanced in a southeasterly direction. Drumlins and striae indicating this direction can be found in Owens and O'Brien Townships south of King's Highway 11 and the Town of Kapuskasing. During the late phase, the ice advanced from the north-northeast and extended much further south than the earlier phase. Both phases together buried most of the previously deposited sediments with a thick layer of clay till, thus creating problems in locating and extracting the aggregate resources.

When final deglaciation occurred, surface drainage followed the regional slope towards James Bay. Surficial deposits of recent age are of minor importance as aggregate sources.

EXTRACTIVE ACTIVITY

There have been over sixty-five sand and gravel pits and four quarries opened in the Kapuskasing Area. Of these, twenty-five pits were found to be active or used in the recent past. The remaining pits and quarries were inactive, abandoned, overgrown, and/or depleted. Portable extraction and processing activities were evident at a number of pits and quarries and one pit had permanent processing facilities which were operating on a continuing basis. Most of the productive pits are found east of the Kapuskasing River. They supply a range of high specification products for road building and construction.

SELECTED SAND AND GRAVEL RESOURCE AREAS – O'BRIEN, TEETZEL, NANSEN, AND FAUQUIER TOWNSHIPS

There are eight resource areas of primary significance located in O'Brien, Teetzel, Nansen, and Fauquier Townships. Seven of these primary areas are part of esker complexes; the eighth is an ice-contact deposit.

The esker systems are important because they contain most of the good quality aggregate in the Kapuskasing Area. The coarse gravel is generally buried beneath massive sandy sediments and a silty clay till. In addition, a high water table makes draglining or water pumping a necessity in many places.

Just east of the Town of Kapuskasing, is a partially buried and fragmented esker. It extends from the northern part of Teetzel Township to the southern part of O'Brien Township and ranges in width from 300 to 3000 feet (91 m to 910 m). A considerable amount of aggregate material has already been extracted from the southern part of O'Brien Township, although resources still remain to the north.

The easternmost esker stretches from the southern border of Nansen Township to southeast of Remi Lake in Fauquier Township. This esker lies along a bedrock fault line along which glacial meltwater probably flowed. The deposit is large in size but not well defined because of burial by silty clay till. Good quality crushable gravel was previously extracted in the northern and central parts of the esker, but substantial resources of coarse aggregate are still available.

The ice-contact deposit in Fauquier Township is only a small feature probably associated with the formation of the large delta deposit. Aggregate is still available, but only in small quantities.

These deposits, selected for possible protection at the primary level, occupy a total of 3700 acres (1500 ha), of which 2260 acres (920 ha) are presently available for extraction. Based on thickness estimates for each resource area, the total available tonnage is estimated to be 186 million tons (169 million tonnes).

Areas of secondary significance are all associated with the existing esker systems. The secondary areas are considered to be less valuable as aggregate sources because of various

quality limitations. However, consideration should be given to their inclusion in resource management strategies for local use, for wayside operations, or in cases where more preferable material is unavailable for extraction.

SELECTED SAND AND GRAVEL RESOURCE AREA 1 – O'BRIEN TOWNSHIP

Selected Sand and Gravel Resource Area 1 is an esker system located to the east of the Town of Kapuskasing. The resource area consists of three disjointed segments that stretch from the northern boundary of the township along the Fred Flatt Road, across King's Highway 11, to just south of Duck Lake.

The largest and best developed of these segments is Resource Area 1a. This segment varies in width from 1500 to 3000 feet (455 to 910 m) and is just over 3 miles (4.8 km) long. There were eleven pits in this deposit, of which only four were active (pits 1, 2, 3, and 4). The active pits had face heights ranging from 5 to 35 feet (1.5 to 11 m). At pit 1, the faces exposed over 30 feet (9 m) of well developed, planar cross-stratified sands. The sands were in the coarse to medium size range and would be suitable for Granular Base Course (G.B.C.) C, concrete, and hot-laid sand products, or for sand cushion (although compaction may be a problem in the latter because of the lack of fines). A permanent asphalt plant was located on the site. Coarser material, although not observed at this pit, has been previously removed below the water table with dragline equipment. Over 5 feet (1.5 m) of clay till was being stripped from the surface when the pit was visited.

Samples were obtained from inactive pit 7 just to the north of pit 1 (Figures 2a and 2b). The coarser pebbly material found at the bottom of the pit was sampled and found to contain 39 percent gravel and 61 percent sand. A range of G.B.C. products could thus be produced. The cross-stratified sand face was also sampled and contained 100 percent fine to medium sand.

Pit 2 was a small active pit on the south shore of Duck Lake. The faces were 5 to 10 feet (1.5 to 3 m) high and exposed fine-grained sand. This material was similar to that found at pit 3. A sample taken from the sand unit in pit 3 (Figure 2b) contained 98 percent sand and 2 percent fines. Most of the sand was fine to medium in size and could be used for G.B.C. C, sand cushion, and sand fill.

Two large pits (pits 4 and 8) had face heights ranging from 12 to 25 feet (4 to 8 m). Pit 4 contained uniform fine to medium sand that was massive to ripple laminated. This unit was located in the upper portions of the esker system throughout the township. Although much of the pit was depleted, it remains active on demand. Bedrock is exposed on the pit floor, thus limiting further resources. Pit 8 was an inactive, overgrown, water-filled pit. Coarse material had been removed by dragline from below the water table. A face-cut located along the water edge exposed stratified, sandy pebble gravel. A sample taken from the cut contained 32 percent gravel, 66 percent sand, and 2 percent fines (Figure 2b). Pit 8 and pit 4 had supplied G.B.C. A and C, 5/8 inch (16 mm) Cr. (crushed) Type A, and Hot-Laid (H.L.) No. 4 stone products in the past according to Ontario Ministry of Transportation and Communications (M.T.C.) records.

Pits 9 and 10 were both inactive, water-filled pits that had an average of 6 feet (2 m) of silty clay till overburden. This till was also noted at the other pits south of Duck Lake. M.T.C. records indicate that coarse and fine aggregate has been removed in the past. However, these pits now appear to be depleted.

Pit 5 was an inactive pit with water on the pit floor. Approximately 16 feet (5 m) of silt clay till overlies 25- to 40-foot (8- to 12-m) sand faces. Crushable gravel was removed from the pit by dragline according to M.T.C. records.

Resource Area 1a occupies a total of 770 acres (310 ha), of which 180 acres (73 ha) are unavailable due to previous extraction and cultural constraints along the lakes. Approximately 590 acres (239 ha) are still available for extractive development and assuming an average thickness of 30 feet (9 m), presently available aggregate resources are estimated to be 44 million tons (40 million tonnes).

Resource Area 1b is divided into two segments. The northern segment is located along the Fred Flatt Road near the O'Brien-Teetzel Township border. Although there were no pits in the O'Brien portion of the deposit, two pits were observed in the same deposit just north of the township line. The aggregate in these pits

ranged from coarse gravel to silty fine sand.

The southern segment of Area 1b is situated north of King's Highway 11 and east of O'Brien Lake. The deposit is a prominent ridge that is approximately 7000 feet (2130 m) long, and 750 feet (229 m) wide. Backhoe testing (OB-TH-2) and (OB-TH-3) showed 8 to 10 feet (2 to 3 m) of silt to silty fine sand buried by a few feet of silty clay material (Figure 2c). This ridge is similar to the northern segment and may contain gravel at a greater depth.

Resource Area 1b occupies 150 acres (61 ha), of which 110 acres (44 ha) are currently available for extraction. Assuming an average thickness of 30 feet (9 m), the presently available aggregate resources are estimated to be 8 million tons (7 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2 – TEETZEL TOWNSHIP

Selected Sand and Gravel Resource Area 2 is a two-part extension of the esker system found in O'Brien Township. The area extends northwards from the southern border of the township along the Fred Flatt Road for approximately 4 miles (6.4 km).

Both parts of Resource Area 2 are approximately 2 miles (3.2 km) long and 1500 feet (455 m) wide. Relief is somewhat subdued because the esker is buried by silty clay till. The most southerly portion of Resource Area 2 contained two active pits (pits 1 and 3). Pit 1, the largest and most developed of the two pits, had face heights ranging from 3 to 25 feet (1 to 8 m). Up to 20 feet (6 m) of clay, fine-grained sand, and pebbly coarse sand had previously been removed from above these exposed faces. Approximately 30 feet (9 m) of water had collected on the pit floor and was being pumped out when the pit was first visited. Well rounded and sorted coarse gravel was being excavated by heavy equipment and processed on the site by a portable crusher. The crushed material was being stockpiled. Samples (Figures 3a and 3c) collected in this pit had gravel contents between 18 to 66 percent. Over 50 percent of the gravel was good quality granitic rock, with nearly 12 percent good quality carbonate rock. The material was acceptable for all G.B.C. products and specific hot-laid asphalt products. Based on observations taken in the newly drained portions of the pit, 25 to 30 feet (8 to 9 m) of coarse gravel may underlie at least half of the pit area.

Pit 3 was a small active sand pit at the time of field investigation. The faces were 12 to 15 feet (4 to 5 m) high and exposed silty fine, fine and medium sand. There was very little overburden at this pit. A sample taken from a representative face contained approximately 85 percent sand and 15 percent fines (Figure 3d). The material would be acceptable for lower specification products such as sand cushion and fill.

There were three active pits (pits 4, 5, and 6) in the northern portion of Resource Area 2. Pit 4 was predominantly sandy with several gravel layers. The face height was 12 feet (4 m) and contained moderately well sorted, stratified sand layers, over cross-stratified gravel layers. A sample (Figure 3b) taken from the coarser material contained 48 percent gravel, 49 percent sand, and 3 percent fines. Much of the gravel had clay coatings. Water was observed at or near the pit floor.

Pit 5, positioned to the south of pit 4, had face heights from 10 to 25 feet (3 to 8 m) high. A face in the esker core had coarse gravel. The gravel was composed of well rounded pebbles with a silt to granule matrix. A sample taken from this material contained 64 percent gravel, 31 percent sand, and 5 percent fines (Figure 3b). Another face on the flank of the esker core exposed horizontally stratified pebbly coarse sand and granule gravel. A sample of the pebbly sand contained 7 percent gravel, 89 percent sand, and 4 percent fines (Figure 3c).

Pit 6, located to the north of an unidentified lake, was about 5 acres (2 ha) in extent and had faces 10 to 35 feet (3 to 11 m) high. One face consisted of horizontally stratified, sandy, small to large pebble gravel. Gravel, located beside a deep water-filled hole in the pit floor, indicated that an even greater thickness of coarse material may be available. Other layers in the deposit were composed of fine gravel and coarse pebbly sand.

Resource Area 2 occupies a total of 350 acres (142 ha), of which 200 acres (81 ha) are available for extraction. Assuming an average deposit thickness of 30 feet (9 m), total aggregate resources are estimated to be 15 million tons (14 million tonnes). Both parts of Resource Area 2 contain good quality gravel suitable for a wide range of uses.

SELECTED SAND AND GRAVEL RESOURCE AREA 3 – TEETZEL TOWNSHIP

Selected Sand and Gravel Resource Area 3 is a northeast- to southwest-trending, buried esker ridge located to the west of Resource Area 2. The ridge extends for approximately 4 miles (6.4 km) and is, on average, 1000 feet (305 m) wide. The area is located along a road maintained by Fern Besner Construction Limited.

Pit 2 was the only pit in the area and was located at the northern end of the Resource Area. The site was a large, active sand and gravel pit with faces at several different levels. The pit consisted of a central ditch with a maximum width of 50 to 100 feet (15 to 30 m), and a depth of 25 to 35 feet (8 to 11 m). The ditch followed the course of the esker northwards for approximately 2000 feet (610 m). Draglining was required in places because of the high water table. Two samples were taken from the main exposed faces (Figure 3a). One sample was from a planar cross-stratified set consisting of gravel. This sample had 41 percent gravel, 54 percent sand, and 5 percent fines. The other sample taken from horizontally stratified gravel had 57 percent gravel, 39 percent sand, and 4 percent fines.

Portable crushing and screening equipment, producing G.B.C. A and C, was operating on the site when pit 2 was visited. M.T.C. records showed that the aggregate product was suitable for G.B.C. B, 5/8 inch (16 mm) Cr. Type A, and H.L. 4 and 8 stone.

The rest of Resource Area 3 has not been exploited and airphoto interpretation indicated that potentially large aggregate resources remain. Resource Area 3 occupies a total of 400 acres (162 ha), of which 265 acres (107 ha) are available for extraction. Assuming an average deposit thickness of 30 feet (9 m), presently available resources of sand and gravel are estimated to be 20 million tons (18 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 4 – TEETZEL TOWNSHIP

Selected Sand and Gravel Resource Area 4 is a thin, buried esker ridge following the Fred Flatt Road in the northern part of Teetzel Township. The ridge is 2 miles (3.2 km) long, approximately 500 feet (152 m) wide, and is flanked by kettle lakes.

The only pit in the area (pit 7), located in the northern end of the deposit, was small and inactive, with slumped faces. The faces were 12 to 15 feet (4 to 5 m) high and exposed sandy material over sandy pebble gravel. Approximately 3 feet (1 m) of clay till overburden covered the deposit. Two testholes (TE-TH-1a, TE-TH-1b) were dug in the pit; TE-TH-1a, in the pit face, contained 47 percent gravel and 53 percent sand, while TE-TH-1b, in the pit floor, contained 52 percent gravel and 48 percent sand (Figure 3b). Petrographic analysis of the coarse aggregate revealed that between 70 and 80 percent of the gravel was granitic-gneiss and 5 to 14 percent carbonate rock. The remaining gravel was made up of minor amounts of quartzite, greywacke-arkose, trap rock, and volcanics. Sand and gravel from pit 7 could be used for a wide range of aggregate products, including G.B.C. products and hot-laid asphalt materials. Another test hole (TE-TH-2), dug into the esker ridge, exposed 5 feet (1.5 m) of clay till over 6 feet (2 m) of fine to medium sand. This sand was the same type of material observed at the uppermost section of pit 7.

Resource Area 4 occupies 150 acres (61 ha); only 80 acres (32 ha) are available for extraction. Assuming an average deposit thickness of 25 feet (8 m), sand and gravel resources total approximately 5 million tons (4 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 5 – NANSEN TOWNSHIP

The only selected area in Nansen Township is an esker system that follows the Chain of Lakes Road from the south to the north end of the township. The esker is divided into two parts based on deposit thickness.

Resource Area 5a is the largest and most developed of the two esker segments. The esker ridge varies in width from 400 to 3900 feet (122 to 1190 m) and has maximum local relief of approximately 50 feet (15 m). There were four active pits observed in Resource Area 5a (pits 1, 2, 3, and 4). Pits 3 and 4 were located in the southern portions of the deposit and both were less than 2 acres (1 ha) in size. Pit 2 was also a small pit. Pit 1 was, on the other hand, a large water-filled pit greater than 25 acres (10 ha) in size. It was located in the northern half of the area. Material at this location had been previously removed by dragline.

The active pits had face heights ranging from 5 to 60 feet (1.5 to 18 m). Above the water table the faces tended to have well sorted sand and silty sand materials. In most cases, a thin veneer of silty clay till was found on top of this material.

At pits 3 and 4, coarse gravel was exposed above the water table. In pit 3, a southern face exposed over 30 feet (9 m) of the esker core. The gravels ranged in size from pebbles to cobbles and made up approximately 60 percent of the face. The clasts were well rounded and nearly all were of Precambrian origin. The overlying and flanking materials around the core tended to be finer. Horizontal, cross-stratified, and ripple laminated fine to coarse sands dominated. At the top of the pit, was a thin veneer of till material.

Pit 4 was shallow, with faces up to 10 feet (3 m) high and showing the upper portions of the esker core. Moderately sorted, cross-stratified gravels were overlain by better sorted and stratified coarse sand. No till was observed on the surface. A test hole (NA-TH-3) dug in the pit floor exposed 3 to 4 feet (1 to 1.2 m) of large pebble to small cobble gravel overlain by 5 to 6 feet (1.5 to 2 m) of medium to coarse sand and underlain by 2 feet (0.6 m) of coarse sand. This material may give some indication of the type of deposit found below the water table at pits 1 and 2. Small stockpiles at pit 2 showed well rounded, cobble-sized gravel of Precambrian origin much the same as at pit 4.

Samples of the coarse aggregate at pits 3 and 4 contain 52 to 73 percent gravel (Figure 4a). With processing, the materials are acceptable for G.B.C. products as well as H.L. 4 stone and sand. At pit 1, the material had been used for G.B.C. A, H.L. 4 stone, and H.L. 2 and 4 sand. Two samples were taken from the pit (Figure 4b). One was of the massive contorted upper unit and had approximately 63 percent sand and 37 percent fines. The other sample, taken from a large stockpile that had been removed from below the water table, had 26 percent gravel, 71 percent sand, and 3 percent fines. A test hole (NA-TH-4), between pits 3 and 4, failed to reveal any aggregate material after 11 feet (3 m) of backhoe digging. Deeper investigation may reveal more positive results. Two other pits (pits 7 and 8) in this deposit were both inactive. Pit 8 was water filled and pit 7 was a small, abandoned, and slumped pit located east of Hastings Lake.

Although considerable amounts of gravel have been removed from Resource Area 5a, especially to the west of Brack Lake, large resources of good quality sand and gravel still remain. The area occupies a total of 950 acres (385 ha), of which approximately 520 acres (210 ha) are presently available for extraction. Assuming an average thickness of 40 feet (12 m), Area 5a contains approximately 52 million tons (47 million tonnes) of sand and gravel.

Resource Area 5b is a further extension southwards of the esker ridge along the Chain of Lakes Road. The area is broken into three parts and extends for almost 4 miles (6.4 km). Only two pits have been opened in this area. One pit was active on demand (pit 5) and the other (pit 6) was inactive. Pit 5 was approximately 3 acres (1 ha) in size and had 12 to 20 feet (4 to 6 m) of well sorted, trough cross-stratified and ripple laminated sand in the upper layers. A till overburden was observed in places. The material became coarser with depth and exposed 3 to 6 feet (1 to 2 m) of trough cross-stratified medium to coarse sand and gravel. A sample taken from the coarser material had 37 percent gravel (Figure 4a). With processing, the material would be acceptable for G.B.C. A and is presently acceptable for G.B.C. B and C. Pit 6 was abandoned, slumped, and water filled. Material above the water consisted of medium to coarse sand. Backhoe testing (NA-TH-1) only uncovered 9 feet (3 m) of till.

Resource Area 5b occupies a total of 275 acres (111 ha), of which 160 acres (65 ha) are available for extraction. Assuming an average thickness of 25 feet (8 m), presently available aggregate resources are estimated to be 10 million tons (9 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 6 – FAUQUIER TOWNSHIP

Selected Sand and Gravel Resource Area 6 is an east-west trending esker that is a branch of the main north-south esker system. The area extends from Bonner Lake to slightly west of Highway 581, south of Remi Lake. This esker ridge is one of the few deposits that is not buried by a thick till overburden. The relief is approximately 35 feet (11 m) and the length is over 2 miles (3.2 km).

There were three active pits in Resource Area 6 (pits 1, 2, and 3). Pit 1 was greater than 20 acres (8 ha) in size and considerable amounts of material have been removed. Much of the pit was water filled. The faces above water ranged from 25 to 50 feet (8 to 15 m) high. The lower units of the face consisted of pebbly coarse sand which fined upwards to medium sand. A sample taken from the lower coarse-grained units consists of approximately 17 percent gravel and 83 percent sand (Figure 5b). The material would be acceptable for G.B.C. products. In some cases, the material may not be acceptable for G.B.C. A because of the fineness of gradation. In the water-filled portion of the pit, crushable aggregate had been removed, according to M.T.C. records.

Pit 2 was a large pit to the east of Highway 581. The eastern portions of the pit were water filled and overgrown, and only in the west were there any active faces. These faces ranged in height from 35 to 40 feet (11 to 12 m). They contained approximately 20 feet (6 m) of sand above alternating layers of gravel and horizontally stratified sand. In places, there was a thin till veneer overlying the pit.

Three samples were taken from sections of the face in pit 2. A coarse sample consisted of 53 percent gravel, 44 percent sand, and 3 percent fines (Figure 5a). Carbonate rock made up over 40 percent of the gravel. The majority of the remaining gravel was made up of granite-gneiss material. The fine samples had 82 percent and 97 percent sand with only a fraction of gravel in the latter sample (Figure 5b). Nearly all products could be obtained from this pit.

The face heights at pit 3 ranged from 25 to 35 feet (8 to 11 m) and exposed sandy material only. The sand was well sorted and became slightly coarser with depth. Water was observed on the pit floor and draglining was used to remove the coarser material. Ontario Ministry of Transportation and Communications' records stated that the finer material was satisfactory for sand cushion and H.L. 4 sand.

Resource Area 6 occupies a total of 350 acres (142 ha), of which approximately 235 acres (95 ha) are presently available for extraction. Assuming an average deposit thickness of 40 feet (12 m), presently available resources of sand and gravel are estimated to be 24 million tons (22 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 7 – FAUQUIER TOWNSHIP

Selected Sand and Gravel Resource Area 7 is an esker complex that stretches from the southern boundary of the township along the Chain of Lakes Road, across King's Highway 11, to the east of South Tower Lake.

Three esker segments have been identified. The northern segment is a single ridge with local relief of approximately 30 feet (9 m). There has been no extraction, but quantities of crushable gravel may be available. In the southern two segments, several pits (pits 4, 6, 7, 8, 9, and 11) have been in operation in the past, but only pit 4 was still active. The face height was 35 feet (11 m) and exposed 5 feet (1.5 m) of silty clay till at the top of the face. Below, was 15 feet (5 m) of fine to coarse sand. The next 15 feet (5 m) exposed sandy, horizontally stratified, pebble gravel with a few cobbles. Water was accumulating on the pit floor. Aggregate used for G.B.C. A, B, and C, 5/8 inch (16 mm) crushed stone and H.L. 4 sand and stone has previously been removed from the pit according to M.T.C. records. A sample from the coarser material contained 64 percent gravel, of which over 90 percent was good quality granitic and gneissic rocks (Figure 5a).

South of pit 4 were two inactive pits (pits 6 and 9). In pit 9, the face was greater than 50 feet (15 m) high and the water table was close to the pit floor. The face exposed 20 feet (6 m) of silty, very fine sand above 15 feet (5 m) of sandy small pebble gravel. The lower 10 to 15 feet (3 to 5 m) was difficult to observe. Pit 6 was a very small sand pit cut into the esker ridge and flanking a small kettle lake. The face was 15 feet (5 m) high, and exposed silt and silty sand underlain by fine to medium sand. These two pits may be acceptable for hot-laid asphalt sand products and fill.

Pits 7, 8, and 11 were slumped and overgrown. The face heights ranged from 10 to 40 feet (3 to 12 m). Most of the exposed material was massive fine sand or medium to coarse sand overlain by a silt clay till with the water table at or near the pit floor. Similar to the other locations, most of the gravel was near or below the water table. Consequently, draglining or pumping the water out of the pit would be necessary for extraction. Pit 8 has yielded sandy pebble gravel in the past, but silt and clay seams

which were located in the pit would be a quality constraint. Pits 7 and 11 do not appear to have supplied much coarse aggregate, if any, and are now virtually depleted.

Resource Area 7 occupies a total of 220 acres (89 ha), of which only 50 acres (20 ha) are available for extraction. Assuming an average thickness of 40 feet (12 m), sand and gravel resources are approximately 5 million tons (4 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 8 – FAUQUIER TOWNSHIP

Selected Sand and Gravel Resource Area 8 is an ice-contact deposit located northwest of the main esker at the northern edge of Remi Lake Provincial Park, along the edge of the massive, ice-contact delta deposit.

Two pits were examined in the area; one active (pit 5) and the other inactive (pit 10). Pit 5 was a small pit exposing sand only. The 20-foot (6-m) face consisted of alternating layers of ripple laminated and planar cross-stratified sands. A sample of the material contained 98 percent sand and 2 percent fines (Figure 5b). Most of the sand was fine to medium in size. Coarse aggregate may occur below the pit floor.

Pit 10 exposed well sorted, horizontally stratified sand with a few areas of thinly bedded, pebble gravel. The pit has supplied G.B.C. B, sand cushion, and H.L. 4 sand products in the past according to M.T.C. records. A sample taken from the main face had 98 percent sand and 2 percent fines (Figure 5c).

Selected Resource Area 8 occupies a total of 65 acres (26 ha), of which 50 acres (20 ha) are available for extraction. Assuming an average deposit thickness of 25 feet (8 m), presently available aggregate resources are estimated to be 3 million tons (3 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE – O'BRIEN, TEETZEL, NANSEN, AND FAUQUIER TOWNSHIPS

Several deposits throughout the townships of O'Brien, Teetzel, Nansen, and Fauquier have been selected as Sand and Gravel Resource Areas of Secondary Significance. These areas are associated with the two esker systems found in the four townships.

O'Brien Township has two secondary areas. The southernmost is found bordering the eastern side of O'Brien Lake along Primary Resource Area 1b. Pit 13, an inactive, abandoned sand pit, is located here and exposes up to 5 feet (1.5 m) of fine to coarse sand. This deposit is part of the esker system, but contains the flanking finer material. A test hole (OB-TH-2), taken in the floor of this pit, contained 81 percent sand and 19 percent fines (Figure 2c). Most of the sand is either fine or silty.

The northernmost secondary area in O'Brien Township had two inactive pits (pits 11 and 12) found adjacent to Primary Resource Area 1b. Both pits had medium sand deposited below a thin clay till overburden. Further sand resources are probably available at these sites. A test hole (OB-TH-5) at pit 12 revealed 98 percent sand and 2 percent fines (Figure 2c).

There are two secondary resource areas in Teetzel Township. One is found between the two sections of Primary Resource Area 2 along the Fred Flatt Road. No pits or test holes were located here, but sand deposits were observed. South of Primary Resource Area 3 is the other secondary deposit where four inactive pits were located (pits 8, 9, 10, and 11). The material here ranged from silty fine sand to coarse sand, but tended to be mainly of the finer variety. Samples from pits 8 and 11 contained between 35 to 100 percent sand with the remaining material being fines (Figure 3c).

In Nansen Township, the secondary area extends along the esker from the southern township boundary to north of Nansen Lake. Most of the subdued ridge is covered by a thick silty clay till and testing (NA-TH-2) exposed 9 feet (3 m) of this material. Further investigation may reveal aggregate resources beneath the till.

Fauquier Township contains two large secondary deposits. The largest is an ice-contact lacustrine delta deposit located south of Remi Lake. The material is made up almost entirely of sand and fines. Water well records indicate sand deposits are up to 75 feet (23 m) thick overlying more than 100 feet (30 m) of sandy bouldery material. A sample taken from the delta at pit 13 contained 60 percent sand and 40 percent fines (Figure 5c).

The other deposit is located east of Bonner Lake. This deposit is a well defined esker ridge composed of medium sand. A sample taken from a small 10-foot (3-m) deep excavation (pit 12) had 98 percent sand and 2 percent fines (Figure 5c). Coarser material may exist at depth.

SELECTED SAND AND GRAVEL RESOURCE AREAS – OWENS, WILLIAMSON, AND IDINGTON TOWNSHIPS

There are four resource areas of primary significance in Owens, Williamson, and Idington Townships (Map 2B). Aggregate resources tend to be located in small esker deposits that have little or no crushable gravel remaining. The esker straddling both Owens and Williamson Townships has previously supplied good quality coarse aggregate, but is now nearing depletion. This is also true of the esker in Idington Township. The one exception is the esker deposit in the northern part of Williamson Township where small reserves of good quality coarse aggregate are still available.

The four Selected Sand and Gravel Resource Areas occupy a total of 740 acres (300 ha), of which 455 acres (184 ha) are presently available for extraction. Total possible resources of sand and gravel are estimated to be 28 million tons (25 million tonnes).

Areas of secondary significance are mainly extensions of existing primary resource areas. Consideration should be given to their inclusion in resource management strategies for local use, for wayside operations, or in cases where preferable material is unavailable for extraction.

SELECTED SAND AND GRAVEL RESOURCE AREA 1 – OWENS TOWNSHIP

Selected Sand and Gravel Resource Area 1 is an esker system which trends north-south in the northwest corner of the township. This buried esker is approximately 1.5 to 2 miles (2.4 to 3.2 km) long and averages 1000 feet (305 m) wide.

Resource Area 1 is divided into two parts with pits 1, 2, and 3 developed in the southern portion. Pit 1 is a small, partially rehabilitated site. The faces were 15 to 20 feet (5 to 6 m) high and exposed up to 10 feet (3 m) of till at the surface. Below, were fine-grained sands, as well as some slightly coarser cross-stratified sands. Close to the base of the face were sandy, small pebble, gravel layers.

There were several stockpiles on the pit floor and a sample was taken from one of them (Figure 6a). The material consisted of coarse sand and granules with abundant, subrounded small pebbles and numerous carbonate clasts. The sample contained 32 percent gravel, 63 percent sand, and 5 percent fines. The material is acceptable for G.B.C. B and C.

At pit 2, most of the faces were slumped. The few intact faces were 15 to 20 feet (5 to 6 m) high, with the top 5 to 10 feet (1.5 to 3 m) being clay till. Below the till was silty sand material which became coarser with depth. At the bottom of the pit was a sandy, small pebble gravel layer with clay coatings on the pebbles. A sample taken from this lower material had 40 percent gravel, 54 percent sand, and 6 percent fines (Figure 6a). The material is acceptable for G.B.C. B and C. With blending, the overlying sand units are acceptable for G.B.C. C and H.L. 4, 5, 6, and 8, according to M.T.C. records. Granular material may still be present below the water table.

Pit 3, the northernmost pit in this area, was completely water filled. The face heights were approximately 25 feet (8 m) above water and exposed 6 to 10 feet (2 to 3 m) of till overlying well sorted sands. Below this level, the material became coarser. A sample from the sandy material contained almost 100 percent fine sand (Figure 6b). In the past, pit 3 had supplied large quantities of coarse aggregate which were found up to 25 feet (8 m) below the water surface (M.T.C.). The material was used for G.B.C. A, 5/8 inch (16 mm) Cr. Type B, and H.L. 4 stone. Because some of the aggregate was silt coated, selection and sand control were required. The removal of any remaining material would be hampered by the large amount of water in the pit.

There were no operating pits in the northern portion of Resource Area 1. However, observations from the surrounding area and airphoto interpretation suggest additional resources are available in this deposit.

Resource Area 1 occupies 175 acres (71 ha), of which 115 acres (46 ha) are available for extraction. Given an average deposit thickness of 40 feet (12 m), present sand and gravel resources total 12 million tons (11 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2 – WILLIAMSON TOWNSHIP

Selected Sand and Gravel Resource Area 2 is an esker deposit located in the north-central part of the township, along Tremblay Road. The area is 0.75 miles (1.2 km) in length and approximately 500 feet (152 m) wide.

There was one active site (pit 3) and two inactive pits (pits 8 and 9) in this deposit. Pit 3 had 15- to 20-foot (5- to 6-m) faces consisting of moderately well sorted sand and gravel. The gravel in pit 3 consisted primarily of Precambrian rock with a significant amount of limestone and siltstone. A sample revealed 27 percent gravel and 73 percent sand (Figure 7a). Granular base course and asphaltic products could be produced from this material.

Pit 8 is located to the southeast of pit 3. The pit was small, approximately 2 acres (1 ha) in size and had water ponding on the pit floor. The faces were 10 feet (3 m) high and showed silty, sandy, small pebble gravel overlain by alternating sequences of coarse pebbly sand and thin silt layers. Another face exposed cross-stratified medium to coarse sand. Various aggregate products can be produced with proper selection.

Pit 9 was an inactive water-filled pit that exposed 5 feet (1.5 m) of fine sand below 3 to 6 feet (1 to 2 m) of clay till. Material draglined from below the water and stockpiled was predominantly sand with some gravel, similar to that observed at pit 3.

Resource Area 2 occupies 120 acres (49 ha), of which 95 acres (38 ha) are presently available for extraction. Assuming a deposit thickness of 20 feet (6 m), total sand and gravel resources are estimated to be 5 million tons (4 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 3 – WILLIAMSON TOWNSHIP

Selected Sand and Gravel Resource Area 3 is an esker system located in the southwest corner of the township. The area is an extension to Resource Area 1 in Owens Township. The esker segment is over 1 mile (1.6 km) long and averages 1500 feet (455 m) in width. The local relief is somewhat subdued because of the till overburden.

There were six pits observed in the area, but only two were active (pits 1 and 2). Pits 1 and 2 were small and contained predominantly sandy material. The 10- to 20-foot (3- to-6 m) faces expose well sorted sand. Samples taken from the faces were primarily sand and fines (Figure 7b). Silt and clay areas were found throughout the deposit. Possible uses for this material include low specification products such as sand cushion and fill. Granular base course might be produced from certain sections.

Inactive pits 4, 5, 6, and 7 contained much the same material as in pits 1 and 2. At pit 7, the faces were 12 to 15 feet (4 to 5 m) high and exposed primarily very well sorted sand with some silt. The material was extensively faulted which is characteristic of ice-contact deposits. Pit 5 was abandoned, overgrown, and partially water filled. The faces exposed fine-grained material similar to other pits in the deposit. Pit 6 was also overgrown, water filled, and exposed till overlying fine-grained sediments. The faces were 15 to 25 feet (5 to 8 m) high and were approximately 95 percent sand. Pit 4 was a small, slumped and abandoned pit. The face heights were 15 to 20 feet (5 to 6 m) and exposed sand only. A considerable thickness of till overburden was noted overlying the sand.

Resource Area 3 occupies a total of 140 acres (57 ha), but because much of the area is depleted, only 70 acres (28 ha) are available for extraction. Assuming a deposit thickness of 25 feet (8 m), present aggregate resources are approximately 4 million tons (4 million tonnes). Further investigation may indicate the presence of coarser aggregate resources.

SELECTED SAND AND GRAVEL RESOURCE AREA 4 – IDINGTON TOWNSHIP

Selected Sand and Gravel Resource Area 4 is a buried esker system located east of the Opasatika River. The esker is fragmented into three parts. One part is north of King's Highway 11 and the other two are located to the south. The esker is approximately 3 miles (4.8 km) long and averages 1000 feet (305 m) in width.

The most southerly portion of the esker had two inactive pits (pits 1 and 2). Pit 1 was extensively slumped and overgrown. Water was observed on the pit floor. The faces were 8 to 10 feet (2 to 3 m) high and exposed massive to

horizontally stratified, silty fine sand, useful only for fill and G.B.C. C purposes. A few small pockets of coarse sand were present.

There were two small excavations at pit 2. The northern pit consisted primarily of silty fine sand with the water table at or near the pit floor. The southern pit exposed predominantly medium sand. A sample taken from the pit had 92 percent sand and 8 percent fines (Figure 8). This material is acceptable for fill and for G.B.C. C in areas where the fines content is not excessive.

The middle section of Resource Area 4 had two inactive pits (pits 5 and 6). They were both overgrown, and had water at or near the pit floor. There was no exposed material in pit 5 except for the silty fine sand in the municipal sanitary disposal area which was once part of the pit. M.T.C. records state that a considerable amount of fine sand was removed. Pit 6 had only one exposed face. It consisted of fairly well sorted, horizontally stratified, fine to medium sand. Coarser material may be found below the water table, but further investigation is required.

The northern section had only one inactive pit (pit 7). Pit 7 was almost completely overgrown and water was found on the pit floor. Faces at one time were over 20 feet (6 m) high according to M.T.C. records. In areas where material was exposed, it consisted of silty sand. A sample taken from the sandy material showed 78 percent sand and 22 percent fines (Figure 8).

Resource Area 4 occupies a total of 305 acres (123 ha), of which 175 acres (71 ha) are available for extraction. Assuming a 15-foot (5-m) deposit thickness for each section, present aggregate resources total approximately 7 million tons (6 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE – OWENS, WILLIAMSON, AND IDINGTON TOWNSHIPS

Areas selected for secondary significance in Owens, Williamson, and Idington Townships either flank, or are extensions of the primary selected areas.

In Owens and Williamson Townships, thin deposits of fine sand occur. There were no pits found in these deposits and no test holes were excavated. The sandy material may be acceptable for low specification products provided the fines content is not too high. In Idington Township, pits 4 and 8 exposed fine to medium sand. The material may only be acceptable for fill.

BEDROCK GEOLOGY

The Kapuskasing Area lies in the Superior Province of the Precambrian Canadian Shield. Most of the bedrock is made up of biotite-quartz-feldspar gneiss and hornblende-quartz-feldspar gneiss which are part of a migmatite-metasedimentary-metavolcanic complex. Granitic intrusive rocks make up the second largest rock group while lesser amounts of metasediments, mafic to intermediate metavolcanics, and diabase dikes are found in various parts within the study area (Bennett et al. 1967a).

Much of the area has an irregular veneer of glacial till with bedrock exposures found throughout. Generally, areas of higher relief have thinner drift cover than the lower lying areas. Drift thickness contour lines shown on Map 3 are derived from water well data, air-photo interpretation and interpretation of the published terrain mapping of the project area (Lee and Scott 1980).

The rocks in the migmatite-metasedimentary-metavolcanic complex (Type B) have a wide range of composition and metamorphic structure (Bennett et al. 1967a). The pre-existing sedimentary rocks were subjected, during metamorphism, to high temperatures and pressures causing deformation and recrystallization which formed biotite-hornblende-quartz-feldspar gneisses and granitic gneisses.

Quarries located within Type B rocks were found to be suitable for a wide range of aggregate products including G.B.C. A, 5/8 inch (16 mm) crushed stone, and H.L. 4 stone, according to M.T.C. records. This rock unit has been selected for resource protection, although care is necessary when using gneisses that are susceptible to chemical and mechanical weathering, especially those with large amounts of biotite, with well developed foliation, and with coarse crystalline texture. Alkali reactions between gneisses and cement paste can lead to deterioration of concrete. This does not, however, pose a problem when these rocks are used for road base applications.

The felsic intrusive rocks (Type A) occur as batholithic intrusions, satellite stocks, and lit-par-lit injection layers within the gneissic complex (Type B) (Bennett et al. 1967a). However, Bennett et al. (1967a) have included lit-par-lit granite in rock Type B because of the usually sharp contact and alternation with gneissic layers. Type A rocks have a wide range in composition and texture and vary from granite to quartz monzonite to granodiorite. The grain size ranges from fine to coarse. Although no quarries in this rock type exist, this material has been quarried in other locations for crushed stone products. Therefore, Type A rocks have been selected for resource protection.

The dominant rock in the metasediment area (Type C) is greywacke. This is a fine-grained, massive to finely bedded, light to dark grey rock with greater than 80 percent quartz and feldspar. The remaining material is made up of biotite, chlorite and sericite. Found within this rock type, are fine-grained argillitic rocks, quartzitic layers, amphiboles, and sandstones (Bennett et al. 1967a). Because of the thick drift cover, the inaccessibility of the rock type, and the fact that other rocks in the area are better suited for aggregate production, Type C rocks have not been selected for resource protection.

The intermediate to mafic metavolcanics (Type D) are fine- to medium-grained, light to dark green, massive to schistose rocks metamorphosed to amphibole, chlorite, or epidote-bearing greenstones. Although these rocks may be suitable for aggregate, drift thickness is generally greater than 25 feet (8 m). Type D rocks, therefore, have not been selected for resource protection.

Diabase dikes (Type E) are scattered throughout the project area and have been selected for resource protection. They are fine- to coarse-grained and gabbroic- to diabasic-textured rocks. One quarry in this rock type produced H.L. 4 stone products. Because these dikes are narrow bedrock features, they have not been calculated into the resource tonnage figures.

SELECTED BEDROCK RESOURCE AREAS – O'BRIEN, TEETZEL, NANSEN, AND FAUQUIER TOWNSHIPS

There are seven areas of Types A and B rock which have been selected for possible resource protection in the townships of O'Brien, Teetzel, Nansen, and Fauquier. These areas are all covered by less than 25 feet (8 m) of drift. The seven resource areas total 30,500 acres (12 300 ha), of which 28,000 acres (11 300 ha) are presently available for potential resource protection. Based on an average quarriable thickness of 60 feet (18 m), the potential crushed stone resources in all areas are estimated to be 6200 million tons (5600 million tonnes).

SELECTED BEDROCK RESOURCE AREA 1 – O'BRIEN TOWNSHIP

Selected Bedrock Resource Area 1 is a large area of Type A bedrock overlain by 3 to 25 feet (1 to 8 m) of drift. The Resource Area consists of two segments; both are located south of King's Highway 11. The topography is generally level and there are few outcrops. There are no quarries in this area and much of the area is bush covered. Road access is provided by Clear Lake Road for one segment and Highway 11 for the other. Tracks of the Canadian National Railways also extend through the latter segment.

Resource Area 1 occupies a total of 1640 acres (660 ha), of which 1500 acres (610 ha) are presently available for extraction. Assuming a workable thickness of 60 feet (18 m), the possible crushed stone resources are estimated to be 335 million tons (305 million tonnes).

SELECTED BEDROCK RESOURCE AREA 2 – O'BRIEN TOWNSHIP

Selected Bedrock Resource Area 2 is a large area of Type B bedrock located north of the Town of Kapuskasing on both sides of the Kapuskasing River. The area is overlain by 3 to 25 feet (1 to 8 m) of drift, however, there are bedrock outcrops especially along the river. Much of the region is low lying with numerous swamps and extensive bush cover.

Area 2 occupies a total of 2470 acres (1000 ha). After deletions for cultural restraints associated with the Town of Kapuskasing and the Kapuskasing River, approximately 2050 acres (830 ha) are presently available for extraction. Based on a quarriable thickness of 60 feet (18 m), crushed stone resources are estimated to be 455 million tons (415 million tonnes). The area is accessible by various permanent and winter roads.

There is one quarry (Q1) in Type B bedrock south of Highway 11, within the town limits of Kapuskasing. The quarry, in an outcrop consisting of micaceous granitic gneiss, has supplied G.B.C. A, 5/8 inch (16 mm) crushed stone, and H.L. 4 stone for many projects in and around Kapuskasing. Abrasion loss may be associated with the presence of mica.

Outcrops are difficult to select because of their size or locality. Consequently, many outcrops, similar to the one in which this quarry is located, have not been selected for resource protection even though the quality of the rock may be good. However, wherever possible, outcrops can be used as quarry sites to fit the local aggregate requirements.

SELECTED BEDROCK RESOURCE AREA 3 – TEETZEL TOWNSHIP

Selected Bedrock Resource Area 3 is a large area of Type B bedrock located in the western and central parts of the township. The area is an extension of Resource Area 2 in O'Brien Township and is covered by 3 to 25 feet (1 to 8 m) of drift although there are areas of 0 to 3 feet (0 to 1 m) of drift. The area is extensively bush covered with low relief and road access is limited throughout. There is no current extractive activity.

Resource Area 3 occupies a total of 14,000 acres (5700 ha), of which 13,300 acres (5400 ha) are currently available for extraction. Assuming a workable thickness of 60 feet (18 m), the total possible crushed stone resources are calculated to be 2950 million tons (2700 million tonnes).

SELECTED BEDROCK RESOURCE AREA 4 – NANSEN TOWNSHIP

Selected Bedrock Resource Area 4 is an area of Type A bedrock located in the northeast corner of the township. The topography is generally level with some areas of outcrop. Access is limited in this bush-covered area, serviced by only a few winter and township boundary roads.

Resource Area 4 occupies a total of 2400 acres (970 ha), of which 2100 acres (850 ha) are available for extraction. Assuming a quarriable thickness of 60 feet (18 m), crushed stone resources are estimated to be 465 million tons (420 million tonnes).

SELECTED BEDROCK RESOURCE AREA 5 – NANSEN TOWNSHIP

Selected Bedrock Resource Area 5, located in Type A bedrock, has 3 to 25 feet (1 to 8 m) of drift cover with a small area having less than 3 feet (1 m). This bush-covered area is located in the southeast portion of the township and is only accessible by rough logging roads.

Resource Area 5 occupies a total of 4450 acres (1800 ha), of which 4150 acres (1680 ha) are currently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), total crushed stone resources are estimated to be 920 million tons (840 million tonnes).

SELECTED BEDROCK RESOURCE AREA 6 – FAUQUIER TOWNSHIP

Selected Bedrock Resource Area 6 is a large area of Type A bedrock located between the western township boundary, near King's Highway 11 and Remi Lake. The area is covered by 3 to 25 feet (1 to 8 m) of drift. This Resource Area extends into O'Brien Township where the bedrock has also been selected for possible resource protection. The land has been partially cleared along the highway but the rest is bush covered. Surface expression is flat, but rock outcrops are common. Road access is excellent throughout the area.

Resource Area 6 occupies 4900 acres (1980 ha), of which 4200 acres (1700 ha) are presently available for extraction. Development is limited in and around Remi Lake due to the presence of residential and recreational properties. Based on a workable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 930 million tons (840 million tonnes).

SELECTED BEDROCK RESOURCE AREA 7 – FAUQUIER TOWNSHIP

Selected Bedrock Resource Area 7 is located in the southeast corner of the township in Type A bedrock and is an extension of Resource Area 4 in Nansen Township. Drift cover is 3 to 25 feet (1 to 8 m) thick and there are several rock outcrops. Access is available mainly in the north where King's Highway 11 and the Canadian National Railways cross the area.

Resource Area 7 occupies 660 acres (265 ha), of which 580 acres (235 ha) are currently available for extraction. Based on a 60-foot (18-m) quarriable thickness, possible crushed stone resources total 129 million tons (117 million tonnes).

SELECTED BEDROCK RESOURCE AREAS – OWENS, WILLIAMSON, AND IDINGTON TOWNSHIPS

There are four areas of Types A and B rock selected for possible resource protection in the townships of Owens, Williamson, and Idington. These areas are covered predominantly by 3 to 25 feet (1 to 8 m) of drift, with small occurrences of 0 to 3 feet (0 to 1 m) of drift cover. Numerous rock outcrops exist throughout the region.

The four resource areas occupy 23,800 acres (9600 ha), of which 21,400 acres (8700 ha) are thought to be available for resource protection. Based on an estimated workable thickness of 60 feet (18 m), the potential crushed stone resources in all areas are estimated to be 4700 million tons (4250 million tonnes).

SELECTED BEDROCK RESOURCE AREA 1 – OWENS TOWNSHIP

Selected Bedrock Resource Area 1 is located in the north-central part of the township in Type B bedrock. The area, overlain by 3 to 25 feet (1 to 8 m) of drift, is heavily bush covered and road access is limited. Quarries have not been developed in the township.

Resource Area 1 occupies a total of 1530 acres (620 ha), of which 1330 acres (540 ha) are presently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), the possible crushed stone resources are estimated to be 295 million tons (270 million tonnes).

SELECTED BEDROCK RESOURCE AREA 2 – WILLIAMSON TOWNSHIP

Selected Bedrock Resource Area 2 is a large area of Type A bedrock located north and south of King's Highway 11 in the western portion of the township. The area is covered by 3 to 25 feet (1 to 8 m) of drift and includes a small area overlain by less than 3 feet (1 m) of drift. Road and rail access dissect the area and bush cover is extensive throughout.

Resource Area 2 occupies a total of 2650 acres (1070 ha), of which 2340 acres (950 ha) are currently available for extraction. Based on a workable thickness of 60 feet (18 m), possible crushed stone resources total 520 million tons (470 million tonnes).

SELECTED BEDROCK RESOURCE AREA 3 – WILLIAMSON TOWNSHIP

Selected Bedrock Resource Area 3 is a large area of Type B gneissic bedrock located north of King's Highway 11 in the central and eastern portion of Williamson Township. The area is covered with 3 to 25 feet (1 to 8 m) of drift with a small area covered by less than 3 feet (1 m). Road access in this bush-covered area is provided by King's Highway 11 and the Tremblay Road.

There were two quarries in the area. Quarry no. Q1 contains granitic gneiss and was operating in the southeast corner of the township. The quarry supplied material for the Kapuskasing Airport. The Ontario Ministry of Transportation and Communications has found the bedrock acceptable for G.B.C. A, 5/8 inch (16 mm) crushed stone, and H.L. 4 stone. The other quarry (Q2) is located near the junction of King's Highway 11 and Tremblay Road, in a diabase dike. The quarry was inactive, but has supplied H.L. 4 stone in the past.

Resource Area 3 occupies 14,700 acres (6000 ha), of which 13,200 acres (5300 ha) are currently available for extraction. Assuming a quarriable thickness of 60 feet (18 m), possible crushed stone resources are estimated to be 2900 million tons (2650 million tonnes).

SELECTED BEDROCK RESOURCE AREA 4 – IDINGTON TOWNSHIP

Selected Bedrock Resource Area 4 is located in the southeast corner of the township south of King's Highway 11 in Type A bedrock. The bedrock is covered by 3 to 25 feet (1 to 8 m) of drift and there are only a few outcrops. The area is bush covered and road access is provided by Cumming Road.

Resource Area 4 occupies 4950 acres (2000 ha), of which 4550 acres (1840 ha) are available for extraction. Based on a quarriable thickness of 60 feet (18 m), the total crushed stone

resources are estimated to be 1010 million tons (920 million tonnes).

SUMMARY

The Kapuskasing Area has twelve deposits of sand and gravel selected for possible resource protection at the primary level. Many of the deposits in the townships to the east of the Kapuskasing River are capable of supplying large amounts of road-building and construction materials. The deposits west of the Kapuskasing River, however, have limited sand and gravel resources remaining.

The project area has an irregular veneer of glacial sediments overlying Precambrian migmatite-metasediment-metavolcanic rocks and felsic intrusive rocks. These two bedrock units are also selected for resource protection because of their capability to produce various types of crushed stone products. These resources may be important, especially in the western townships, where resources of crushable gravel are becoming scarce.

Enquiries regarding the Aggregate Resources Inventory of the Kapuskasing Area should be directed to the Ontario Ministry of Natural Resources, either at the Kapuskasing District Office, 6 Government Road, Kapuskasing, Ontario, P5N 2W4 (Tel. (705) 335-6191) or at the Northern Region Office, 60 Wilson Avenue, Timmins, Ontario, P4N 2S7 (Tel. (705) 267-1401).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, KAPUSKASING AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
O'BRIEN TOWNSHIP			
1	G-E	150 (61)	11 (10)
	S-E	1140 (460)	57 (52)
		1290 (520)	68 (62)
TEETZEL TOWNSHIP			
1	G-E	900 (365)	65 (59)
	S-E	235 (95)	15 (14)
2	S-E	80 (32)	3 (3)
		1220 (495)	83 (75)
NANSEN TOWNSHIP			
1	G-E	1220 (495)	110 (100)
	S-E	470 (190)	24 (22)
		1690 (680)	134 (122)
FAUQUIER TOWNSHIP			
1	G-E	570 (231)	57 (52)
	S-E	167 (68)	8 (7)
	S-IC	65 (26)	4 (4)

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, KAPUSKASING AREA

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
FAUQUIER TOWNSHIP			
	S-IC-LD	2500 (1010)	380 (345)
		3300 (1340)	450 (410)
OWENS TOWNSHIP			
1	G-E	175 (71)	18 (16)
2	S-E	135 (55)	6 (5)
		310 (126)	24 (22)
WILLIAMSON TOWNSHIP			
1	S-E	260 (105)	13 (12)
2	S-E	460 (186)	17 (15)
		720 (290)	30 (27)
IDINGTON TOWNSHIP			
1	S-E	305 (123)	15 (14)
2	S-E	92 (37)	2 (2)
	S-IC	100 (40)	2 (2)
		495 (200)	19 (17)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, KAPUSKASING AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
O'BRIEN TOWNSHIP							
1	K11-22	Fern Besner Construction Ltd.	12	7, 8	25-35 (8-11)	sand	
2	–	M.T.C.	12	3	5-10 (1.5-3)	sand	
3	K11-49	M.T.C.	12	2	25-35 (8-11)	sand	
4	K11-3	M.T.C.	12	3	12-25 (4-8)	sand	
5	K11-25	M.T.C.	11	6	25-40 (8-12)	sand	
6	K11-32	M.T.C.	12	3, 4	10-12 (3-4)	–	
7	K11-48	Unknown	11, 12	8	20-25 (6-8)	0-40	
8	K11-47	M.T.C.	12	3	12-15 (4-5)	0-35	
9	K11-19	Unknown	12	4, 5	6 (2) (overburden)	–	water filled
10	K11-27	J. Ouellette	12	6	10-15 (3-5)	–	water filled
11	K11-17	Nadeau	10	17	5-12 (1.5-4)	sand	
12	K11-20	Nadeau	9, 10	15, 16	5-12 (1.5-4)	sand	
13	K11-36	Guenette	11	11, 12	0-5 (0-1.5)	sand	
14	K11-41	Guillemette	11	6	–	–	
15	–	Unknown	19, 20	17	–	–	

TABLE 2 | SAND AND GRAVEL PITS, KAPUSKASING AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT*	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
TEETZEL TOWNSHIP							
1	K11-15	Crown (Quarry Permit (Q.P.) to Labelle)			3-25 (1-8)	20-70	
2	–	Crown (Q.P. to Fern Besner Construction Ltd.)			25-35 (8-11)	40-60	
3	–	Crown (Q.P. to L. Dumais)			12-15 (4-5)	sand	
4	–	Crown (Q.P. to F. Nadeau and Son)			12 (4)	50	
5	–	Crown (Q.P. to F. Nadeau and Son)			10-25 (3-8)	10-65	
6	–	Crown (Q.P. to Dumais and Son)			10-35 (3-11)	–	
7	–	Crown (Q.P. to R. Dufour)			12-15 (4-5)	45-50	overgrown
8	K11-21	Crown			9-12 (3-4)	sand	
9	–	Crown			–	sand	
10	K11-17	Crown			20-35 (6-11)	sand	
11	–	Crown			–	sand	

* Lots and concessions are unavailable because the township is not subdivided.

TABLE 2 | SAND AND GRAVEL PITS, KAPUSKASING AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
NANSEN TOWNSHIP							
1	K11-11	LaBelle	18	12	15-60 (5-18)	0-30	
2	K11-46	G. Credger	E½ 19	11	12-35 (4-11)	mainly sand	
3	–	Crown (Q.P. to Township of Fauquier)	21, 22	8	25-35 (8-11)	50-75	
4	–	Crown (Q.P. to Spruce Falls Power & Paper Co. Ltd.)	21, 22	7	5-10 (2-3)	50-75	
5	–	Crown (Q.P. to Spruce Falls Power & Paper Co. Ltd.)	23	3	12-20 (4-6)	0-40	
6	–	Crown	21, 22	6, 7	–	–	water filled
7	K11-30	K. Wilker	20	9	–	–	abandoned
8	K11-53	A. Tremblay, J. Charette	18	12	–	–	water filled
FAUQUIER TOWNSHIP							
1	K11-23	Fern Besner Construction Ltd.	13	6	25-50 (8-15)	0-20	partly water filled
2	K11-4	M.T.C.	11	6	35-40 (11-12)	0-55	partly water filled
3	K11-40 K11-5	R. Filion Crown	10	5, 6	26-35 (8-11)	sand	
4	K11-35	U. Charpentier	E½ 16	3	35 (11)	65	
5	–	Unknown	16	7	20 (6)	sand	
6	–	Unknown	17	1	15 (5)	sand	

TABLE 2 | SAND AND GRAVEL PITS, KAPUSKASING AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
FAUQUIER TOWNSHIP							
7	K11-10	J. Cedger	16E	2	35-40 (11-12)	–	overgrown
8	K11-16	M.T.C.	W½ 16	2	20-25 (6-8)	–	overgrown
9	K11-14	A. Godin	16, 17	1	50 (15)	mainly sand	
10	K11-39	Crown	16	6	25 (8)	sand	
11	–	Unknown	15	2	10 (3)	–	overgrown
12	–	M.N.R.	7	6	10 (3)	sand	
13	–	Unknown	19	6	road-cut	sand	
OWENS TOWNSHIP							
1	L17-13	M.T.C.	23	17	15-20 (5-6)	30	partly rehabilitated
2	L17-23	Crown	24	15	15-20 (5-6)	40	partly overgrown and water filled
3	L17-11	M.T.C.	24	16	25 (8) (above water)	sand	
WILLIAMSON TOWNSHIP							
1	LR17-24	M.T.C. P. Filion	25	2	10-15 (3-5)	sand	
2	LR17-22	Crown (Q.P. to A. Tremblay)	26, 27	1	12-20 (4-6)	sand	
3	–	Crown (Q.P. to Spruce Falls Power & Paper Co. Ltd.)	12, 13	17	15-20 (5-6)	30	

TABLE 2 | SAND AND GRAVEL PITS, KAPUSKASING AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 % GRAVEL	8 PIT STATUS
WILLIAMSON TOWNSHIP							
4	LR17-17	M.T.C.	25, 26	2	15-20 (5-6)	sand	
5	LR17-1	Unknown	25	3	–	–	overgrown and partly water filled
6	LR17-16	Unknown	26	2	15-25 (5-8)	sand	overgrown and water filled
7	LR17-15	Unknown	26	2	12-15 (4-5)	sand	
8	O17-4	Crown (Q.P. to J. Tremblay)	12	15, 16	10 (3)	–	
9	–	Crown (Q.P. to A. Tremblay)	15, 16	18	10 (3)	sand	
IDINGTON TOWNSHIP							
1	–	Unknown	25	8	8-10 (2-3)	sand	overgrown
2	O17-6	R. Dumais	24, 25	7, 8	8-10 (2-3)	sand	
3	–	Unknown	23	9	15 (5)	–	
4	–	Crown	17, 18	12	10 (3)	sand	
5	O17-1	Crown	22	10	3-8 (1-2)	sand	overgrown
6	O17-7	Bernard	21	10	–	sand	
7	O17-8	Chevier	20	10	–	sand	overgrown
8	O17-9	Gauthier	19	11	–	sand	
9	–	Crown	10	8	–	–	

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, KAPUSKASING AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
O'BRIEN TOWNSHIP						
1a	770 (310)	50 (20)	130 (53)	590 (239)	30 (9)	44 (40)
1b	150 (61)	40 (16)	0 (0)	110 (44)	30 (9)	8 (7)
	920 (370)	90 (36)	130 (53)	700 (285)		52 (47)
TEETZEL TOWNSHIP						
2	350 (142)	125 (51)	25 (10)	200 (81)	30 (9)	15 (14)
3	400 (162)	75 (30)	60 (24)	265 (107)	30 (9)	20 (18)
4	150 (61)	70 (28)	0 (0)	80 (32)	25 (8)	5 (4)
	900 (365)	270 (109)	85 (34)	540 (218)		40 (36)
NANSEN TOWNSHIP						
5a	950 (385)	400 (162)	30 (12)	520 (210)	40 (12)	52 (47)
5b	275 (111)	110 (44)	5 (2)	160 (65)	25 (8)	10 (9)
	1220 (495)	510 (206)	35 (14)	680 (275)		62 (56)

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, KAPUSKASING AREA

1 DEPOSIT NO.	2 AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
FAUQUIER TOWNSHIP						
6	350 (142)	80 (32)	35 (14)	235 (95)	40 (12)	24 (22)
7	220 (89)	140 (57)	30 (12)	50 (20)	40 (12)	5 (4)
8	65 (26)	10 (4)	5 (2)	50 (20)	25 (8)	3 (3)
	640 (260)	230 (93)	70 (28)	335 (136)		32 (29)
OWENS TOWNSHIP						
1	175 (71)	50 (20)	10 (4)	115 (46)	40 (12)	12 (11)
WILLIAMSON TOWNSHIP						
2	120 (49)	15 (6)	10 (4)	95 (38)	20 (6)	5 (4)
3	140 (57)	55 (22)	15 (6)	70 (28)	25 (8)	4 (4)
	260 (105)	70 (28)	25 (10)	165 (67)		9 (8)
IDINGTON TOWNSHIP						
4	305 (123)	115 (46)	15 (6)	175 (71)	15 (5)	7 (6)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, KAPUSKASING AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
O'BRIEN TOWNSHIP				
3-25 (1-8)	A	60 (18)	1640 (660)	365 (330)
3-25 (1-8)	B	60 (18)	3650 (1480)	810 (740)
			5300 (2140)	1180 (1070)
TEETZEL TOWNSHIP				
0-3 (0-1)	B	60 (18)	1020 (415)	226 (205)
3-25 (1-8)	B	60 (18)	15,500 (6300)	3450 (3150)
			16,500 (6700)	3700 (3350)
NANSEN TOWNSHIP				
0-3 (0-1)	A	60 (18)	245 (99)	54 (49)
3-25 (1-8)	A	60 (18)	6600 (2650)	1460 (1320)
			6800 (2750)	1510 (1370)
3-25 (1-8)	B	60 (18)	18,500 (7500)	4100 (3700)
3-25 (1-8)	D	60 (18)	400 (162)	89 (81)
			25,700 (10 400)	5700 (5200)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, KAPUSKASING AREA

1 DRIFT THICKNESS Feet (Metres)	2 BEDROCK LITHOLOGY	3 QUARRIABLE THICKNESS Feet (Metres)	4 AREAL EXTENT Acres (Hectares)	5 ORIGINAL TONNAGE Millions of Tons (Tonnes)
FAUQUIER TOWNSHIP				
3-25 (1-8)	A	60 (18)	5600 (2270)	1240 (1120)
3-25 (1-8)	B	60 (18)	22,400 (9100)	4950 (4500)
			28,000 (11 300)	6200 (5600)
OWENS TOWNSHIP				
3-25 (1-8)	A	60 (18)	130 (53)	29 (26)
3-25 (1-8)	B	60 (18)	6200 (2500)	1380 (1250)
			6300 (2550)	1410 (1280)
WILLIAMSON TOWNSHIP				
0-3 (0-1)	A	60 (18)	90 (36)	20 (18)
3-25 (1-8)	A	60 (18)	2550 (1030)	570 (520)
			2650 (1070)	590 (540)
0-3 (0-1)	B	60 (18)	265 (107)	59 (54)
3-25 (1-8)	B	60 (18)	16,900 (6800)	3750 (3400)
			17,200 (7000)	3800 (3450)
3-25 (1-8)	C	60 (18)	3800 (1540)	840 (760)
			23,600 (9600)	5200 (4700)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, KAPUSKASING AREA

1 **DRIFT THICKNESS** Feet (Metres)	2 **BEDROCK LITHOLOGY**	3 **QUARRIABLE THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
IDINGTON TOWNSHIP				
3-25 (1-8)	A	60 (18)	5100 (2060)	1130 (1020)
3-25 (1-8)	B	60 (18)	13,200 (5300)	2950 (2700)
			18,300 (7400)	4100 (3700)

TABLE 5 | QUARRIES, KAPUSKASING AREA

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 FACE HEIGHT Feet (Metres)	7 QUARRY STATUS
O'BRIEN TOWNSHIP						
Q1	K11-18	Powers (LaBelle)	18	11	4-6 (1-2)	
TEETZEL TOWNSHIP						
		– NONE –				
NANSEN TOWNSHIP						
		– NONE –				
FAUQUIER TOWNSHIP						
		– NONE –				
OWENS TOWNSHIP						
		– NONE –				
WILLIAMSON TOWNSHIP						
Q1	K11-6	McNamara Const. (LaBelle)	1	1		
Q2	LR17-7	M.T.C.	11, 12	1		
IDINGTON TOWNSHIP						
Q1	017-10	LaBelle	11	8		

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, KAPUSKASING AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
O'BRIEN TOWNSHIP							
1	3-25 (1-8)	1640 (660)	140 (57)	0 (0)	1500 (610)	60 (18)	335 (305)
2	3-25 (1-8)	2470 (1000)	420 (170)	0 (0)	2050 (830)	60 (18)	455 (415)
		4100 (1660)	560 (227)	0 (0)	3550 (1440)		790 (720)
TEETZEL TOWNSHIP							
3	0-25 (0-8)	14,000 (5700)	710 (285)	0 (0)	13,300 (5400)	60 (18)	2950 (2700)
NANSEN TOWNSHIP							
4	3-25 (1-8)	2400 (970)	300 (121)	0 (0)	2100 (850)	60 (18)	465 (420)
5	0-25 (0-8)	4450 (1800)	300 (121)	0 (0)	4150 (1680)	60 (18)	920 (840)
		6800 (2750)	600 (243)	0 (0)	6200 (2500)		1380 (1250)

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, KAPUSKASING AREA

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED QUARRIABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
FAUQUIER TOWNSHIP							
6	3-25 (1-8)	4900 (1980)	700 (285)	0 (0)	4200 (1700)	60 (18)	930 (840)
7	3-25 (1-8)	660 (265)	80 (32)	0 (0)	580 (235)	60 (18)	129 (117)
		5600 (2270)	780 (315)	0 (0)	4800 (1940)		1060 (960)
OWENS TOWNSHIP							
1	3-25 (1-8)	1530 (620)	200 (81)	0 (0)	1330 (540)	60 (18)	295 (270)
WILLIAMSON TOWNSHIP							
2	0-25 (0-8)	2650 (1070)	300 (121)	0 (0)	2340 (950)	60 (18)	520 (470)
3	0-25 (0-8)	14,700 (6000)	1510 (610)	7 (3)	13,200 (5300)	60 (18)	2900 (2650)
		17,400 (7000)	1810 (730)	7 (3)	15,500 (6300)		3400 (3100)
IDINGTON TOWNSHIP							
4	3-25 (1-8)	4950 (2000)	400 (162)	0 (0)	4550 (1840)	60 (18)	1010 (920)

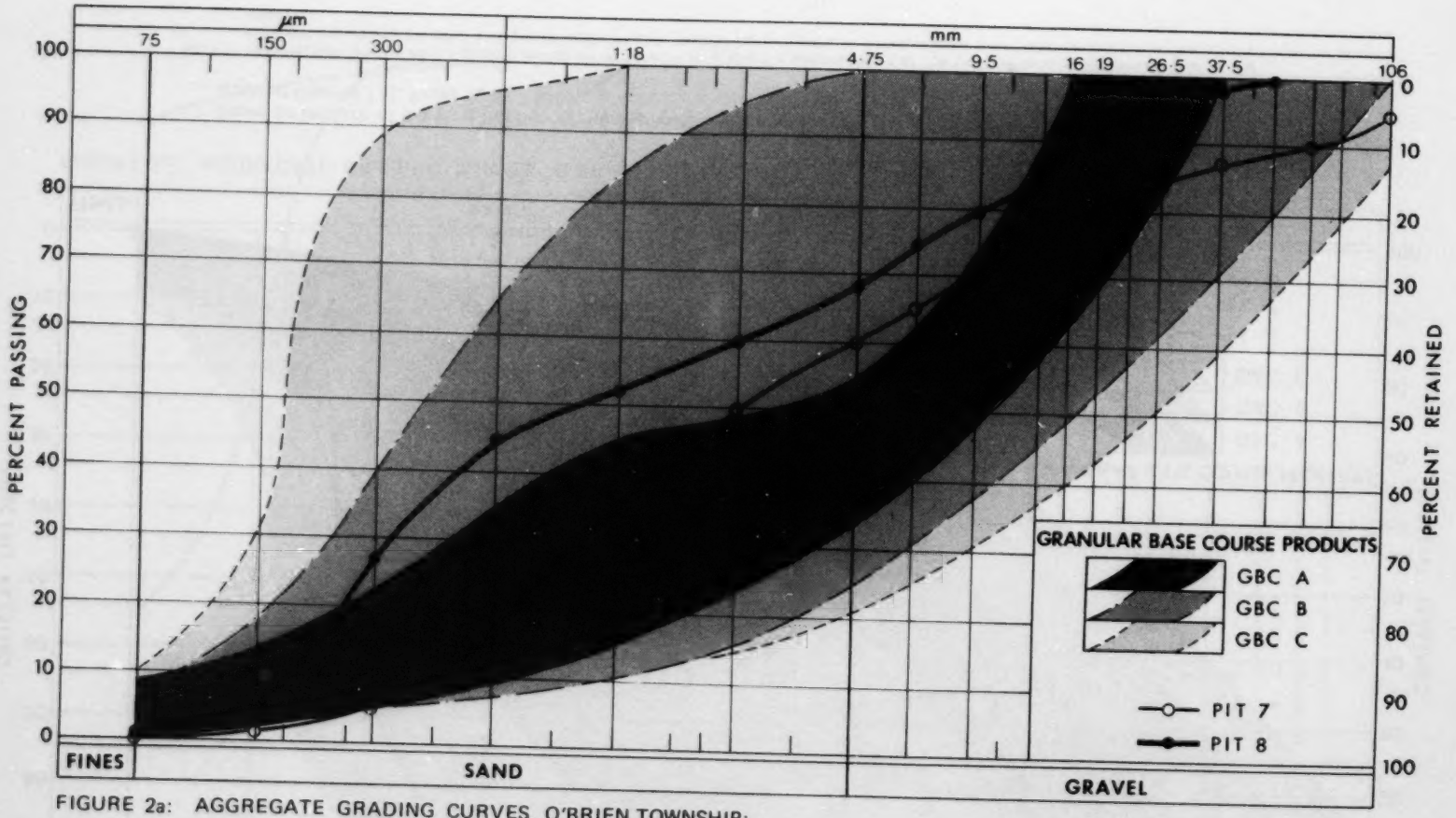


FIGURE 2a: AGGREGATE GRADING CURVES, O'BRIEN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

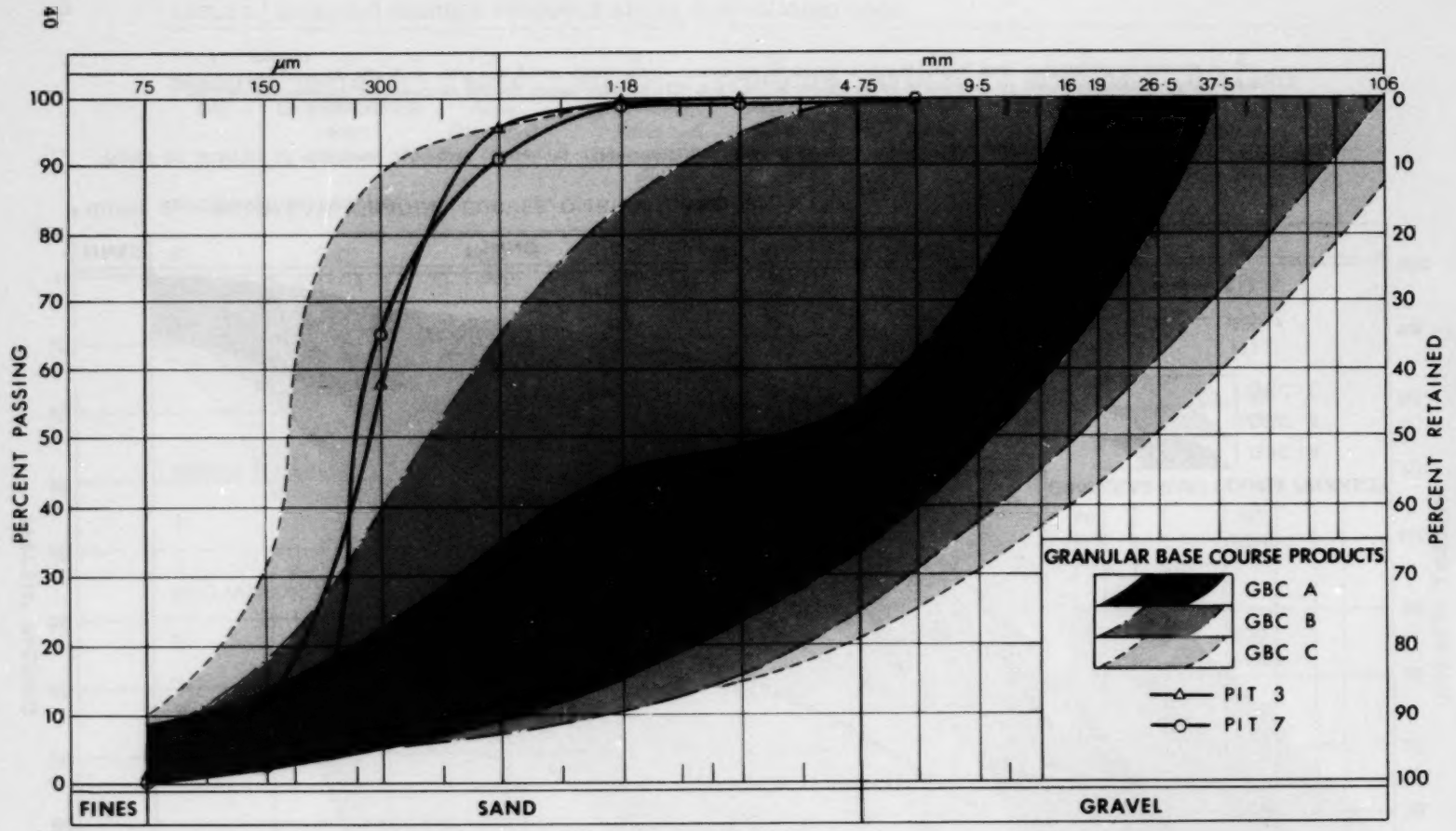


FIGURE 2b: AGGREGATE GRADING CURVES, O'BRIEN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

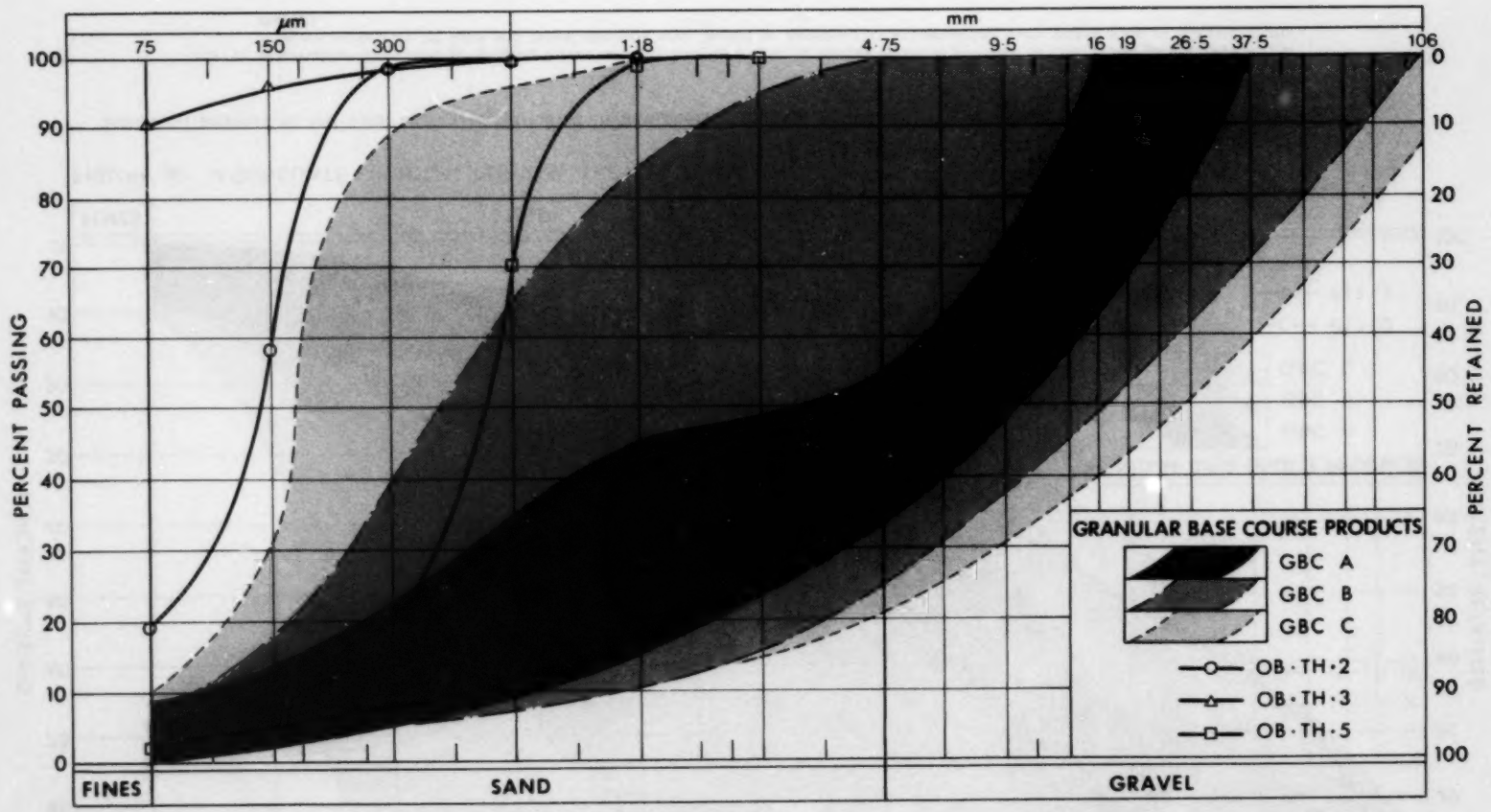


FIGURE 2c: AGGREGATE GRADING CURVES, O'BRIEN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

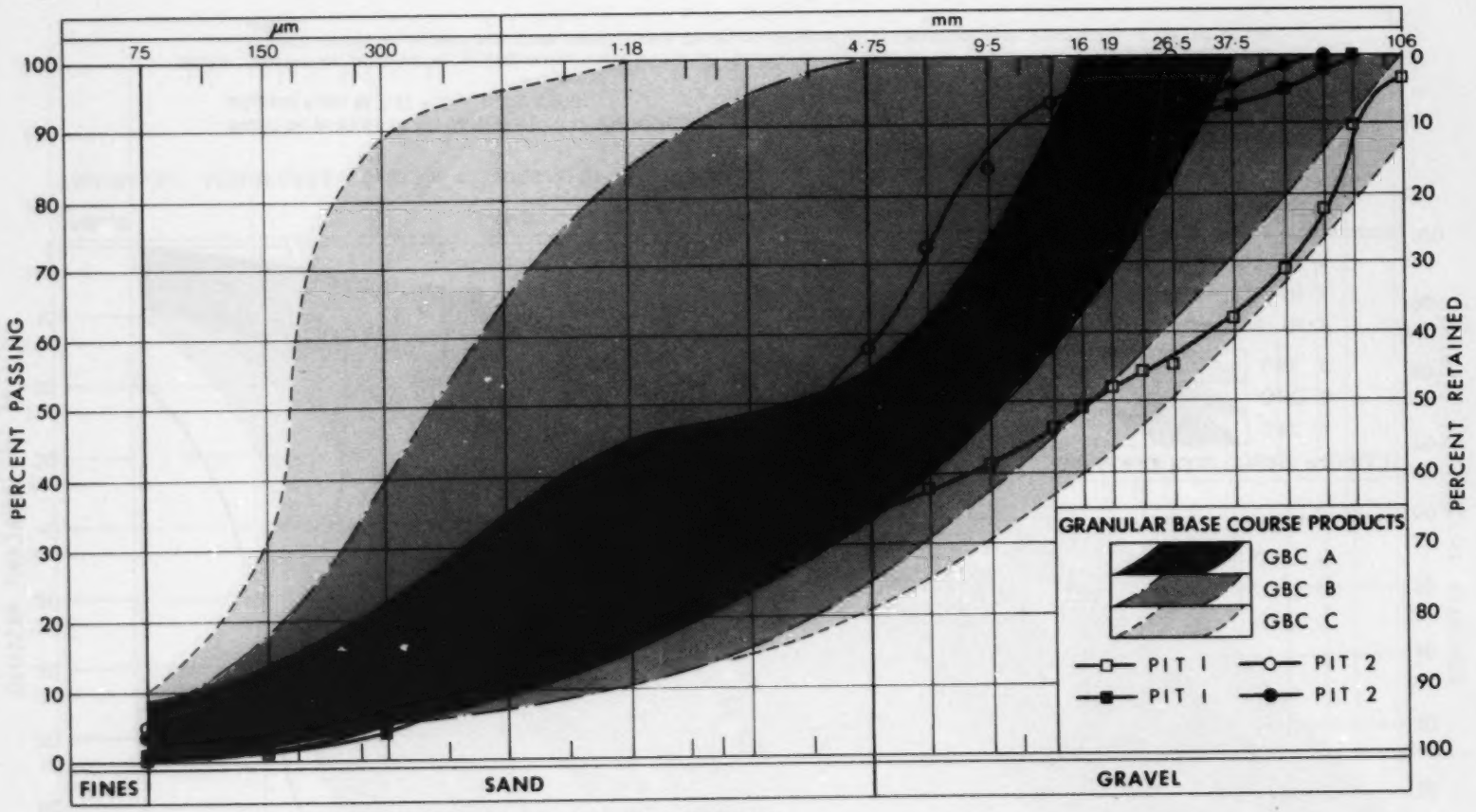


FIGURE 3a: AGGREGATE GRADING CURVES, TEETZEL TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

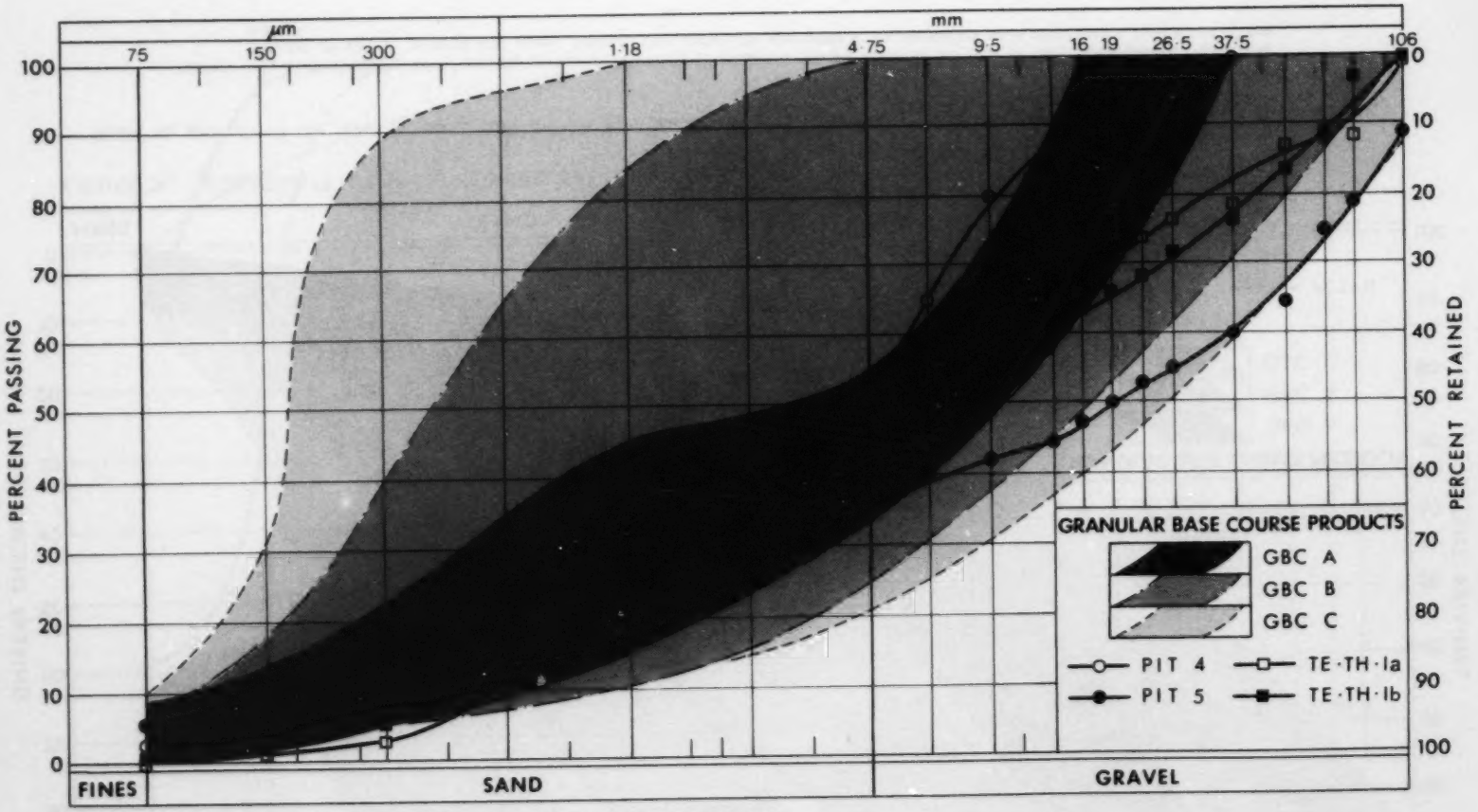


FIGURE 3b: AGGREGATE GRADING CURVES, TEETZEL TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

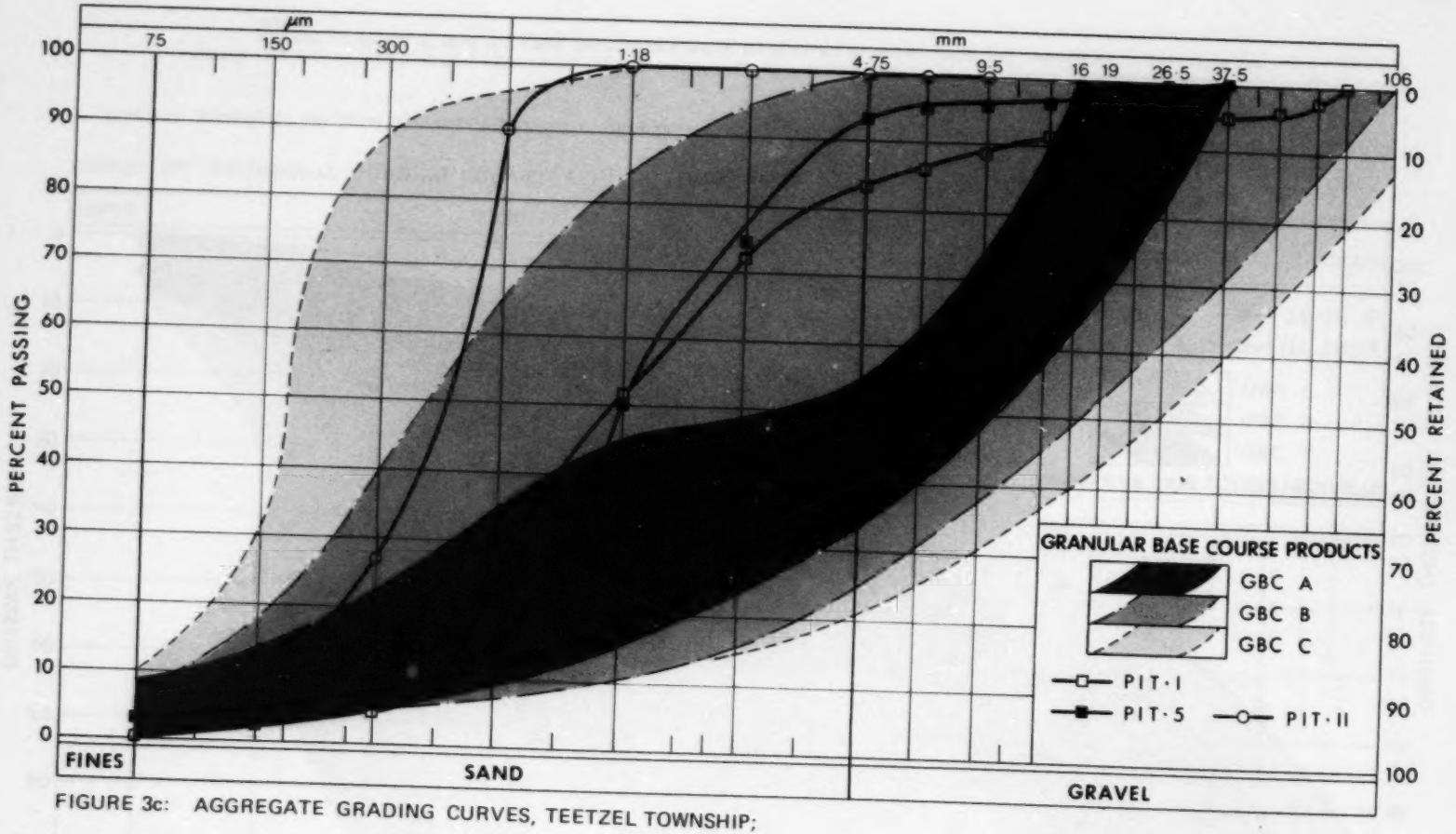


FIGURE 3c: AGGREGATE GRADING CURVES, TEETZEL TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

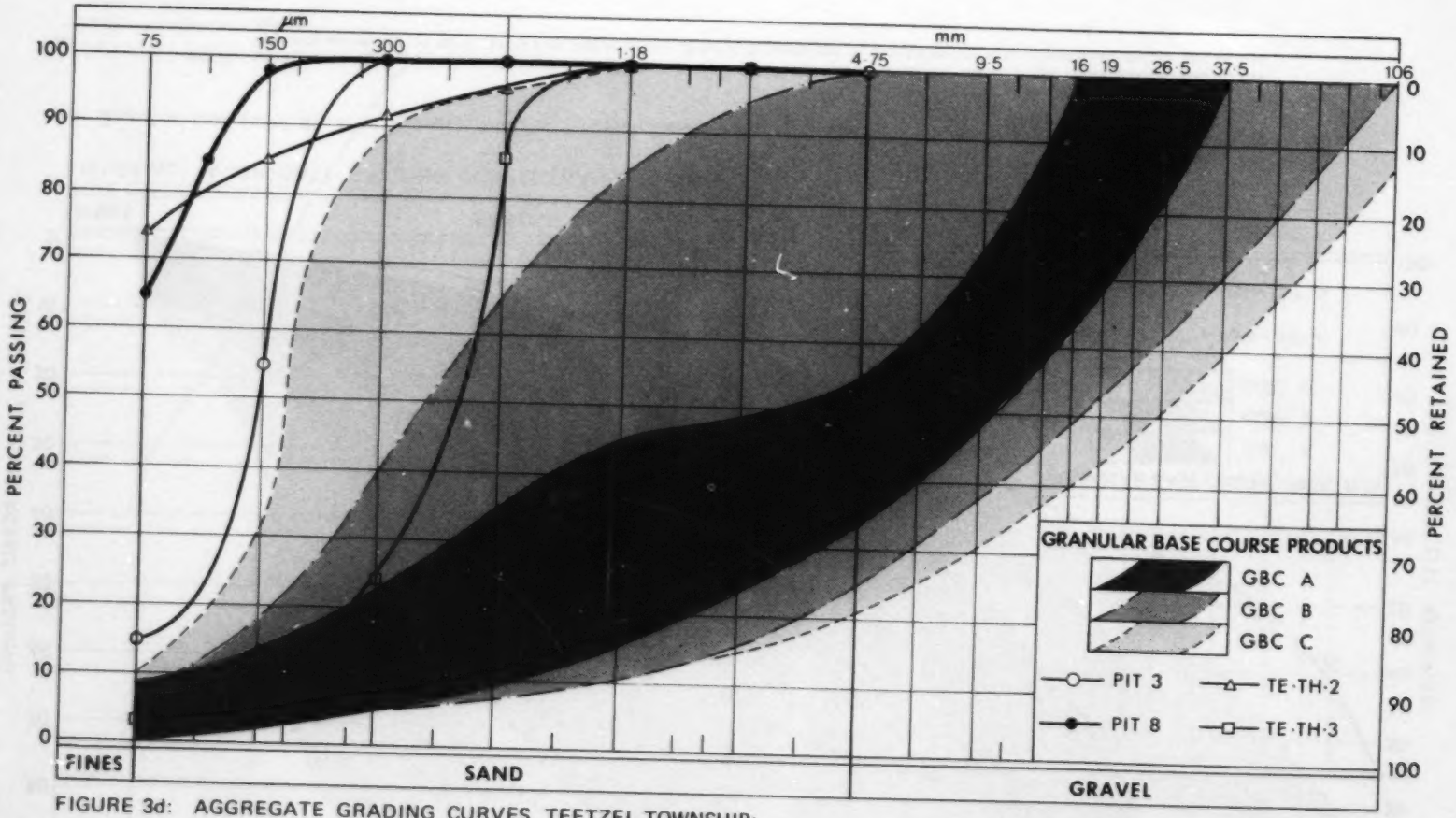


FIGURE 3d: AGGREGATE GRADING CURVES, TEETZEL TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

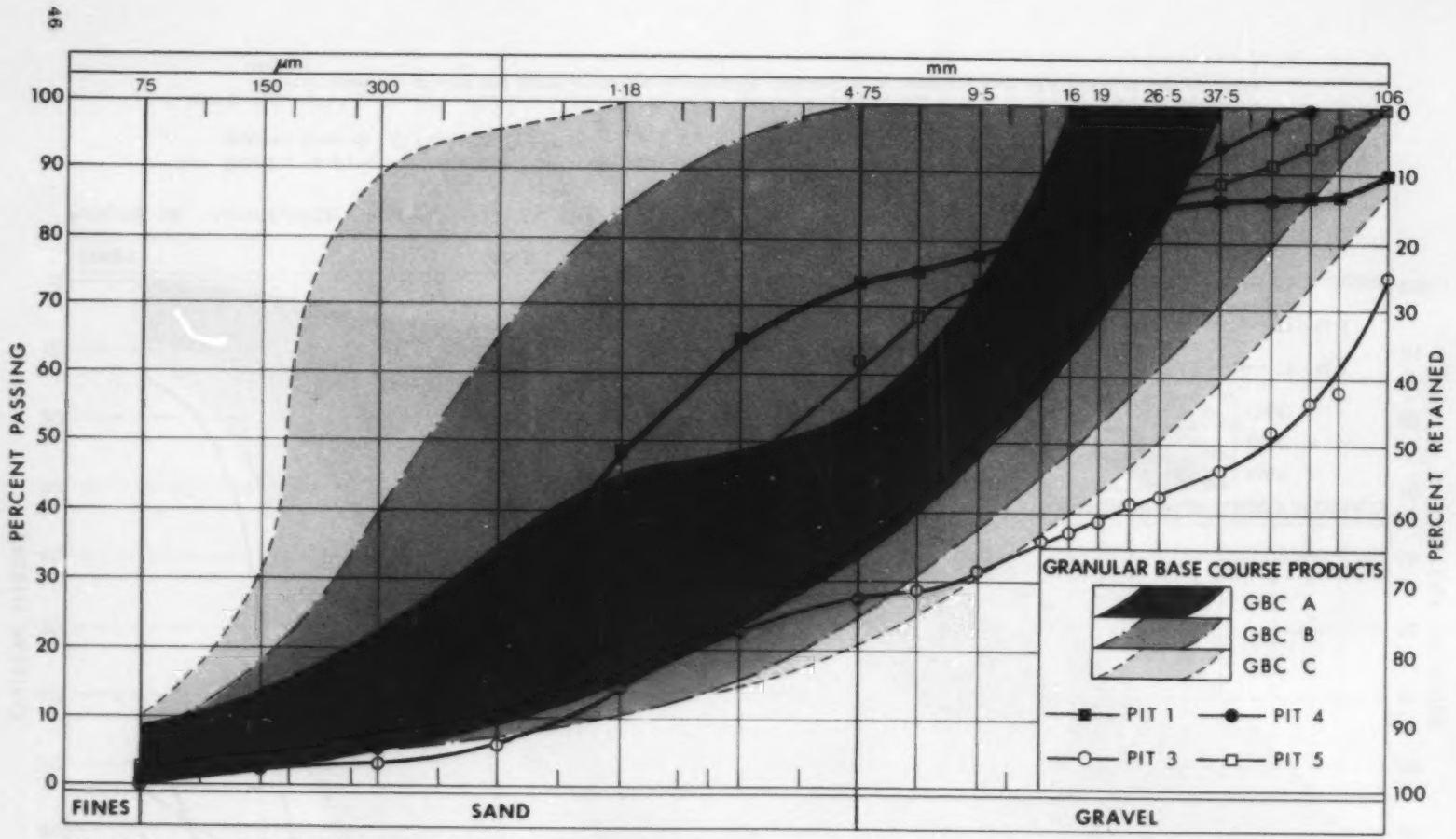


FIGURE 4a: AGGREGATE GRADING CURVES, NANSEN TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

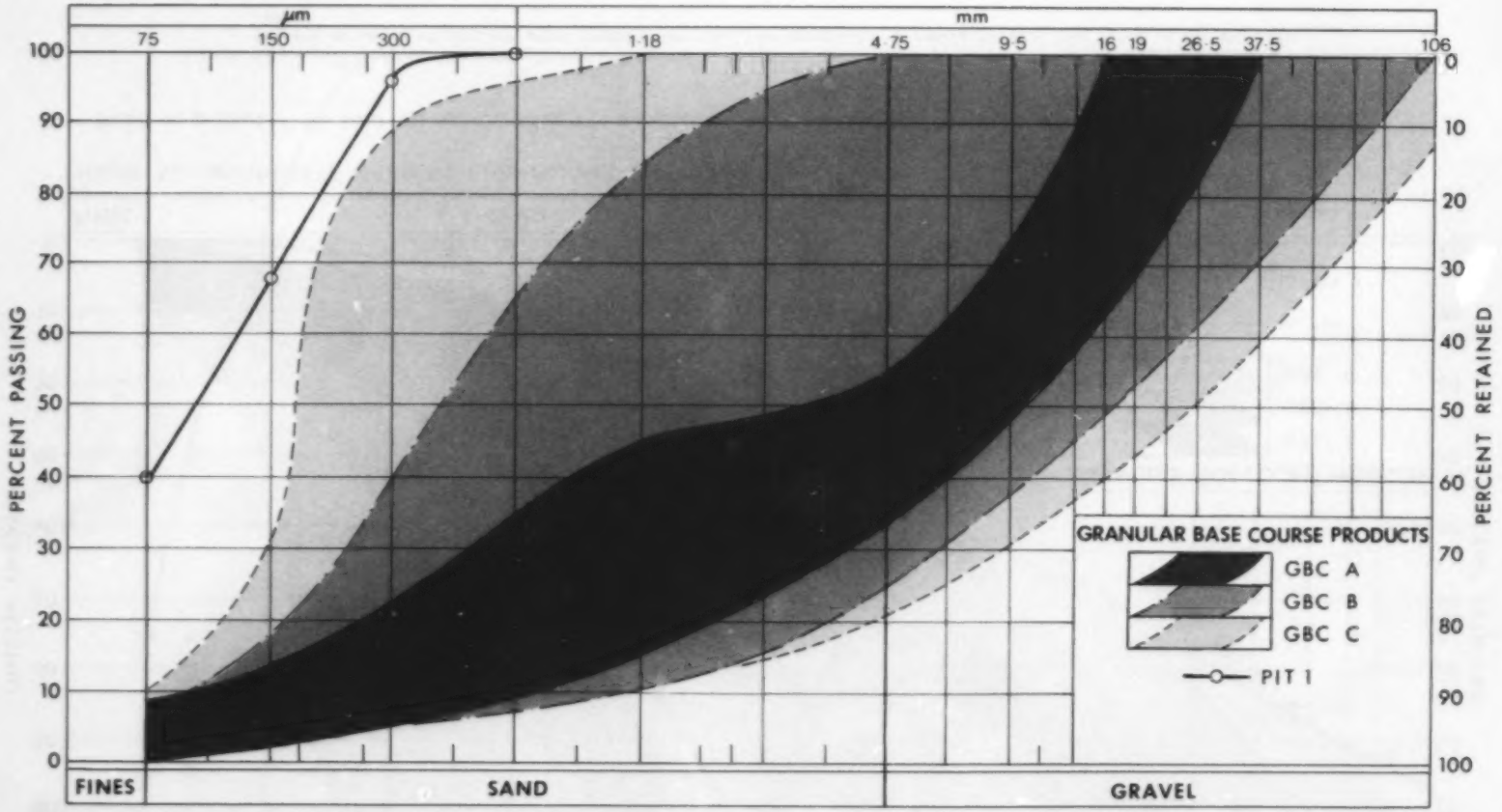


FIGURE 4b: AGGREGATE GRADING CURVES, NANSEN TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

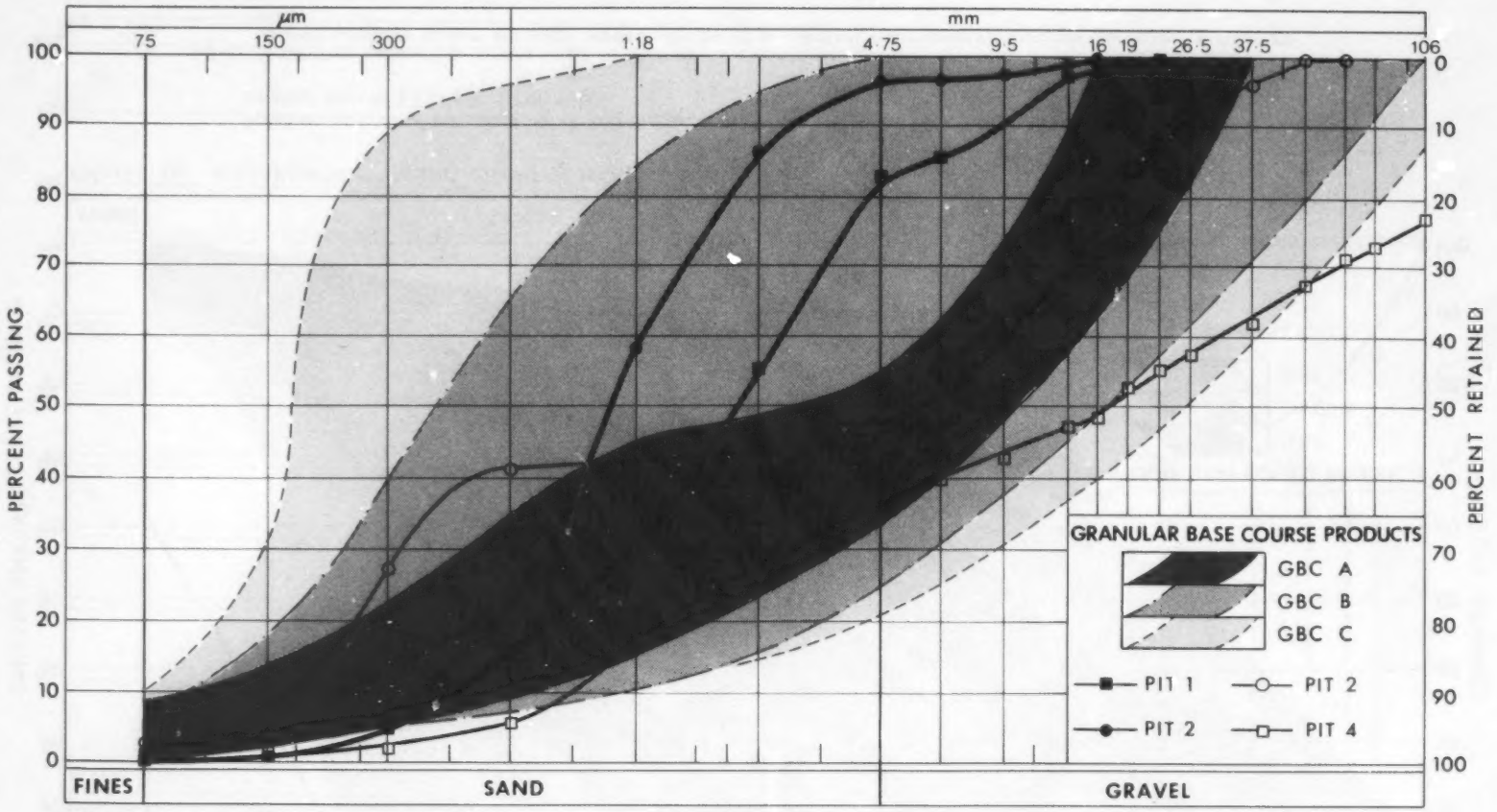


FIGURE 5a: AGGREGATE GRADING CURVES, FAUQUIER TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

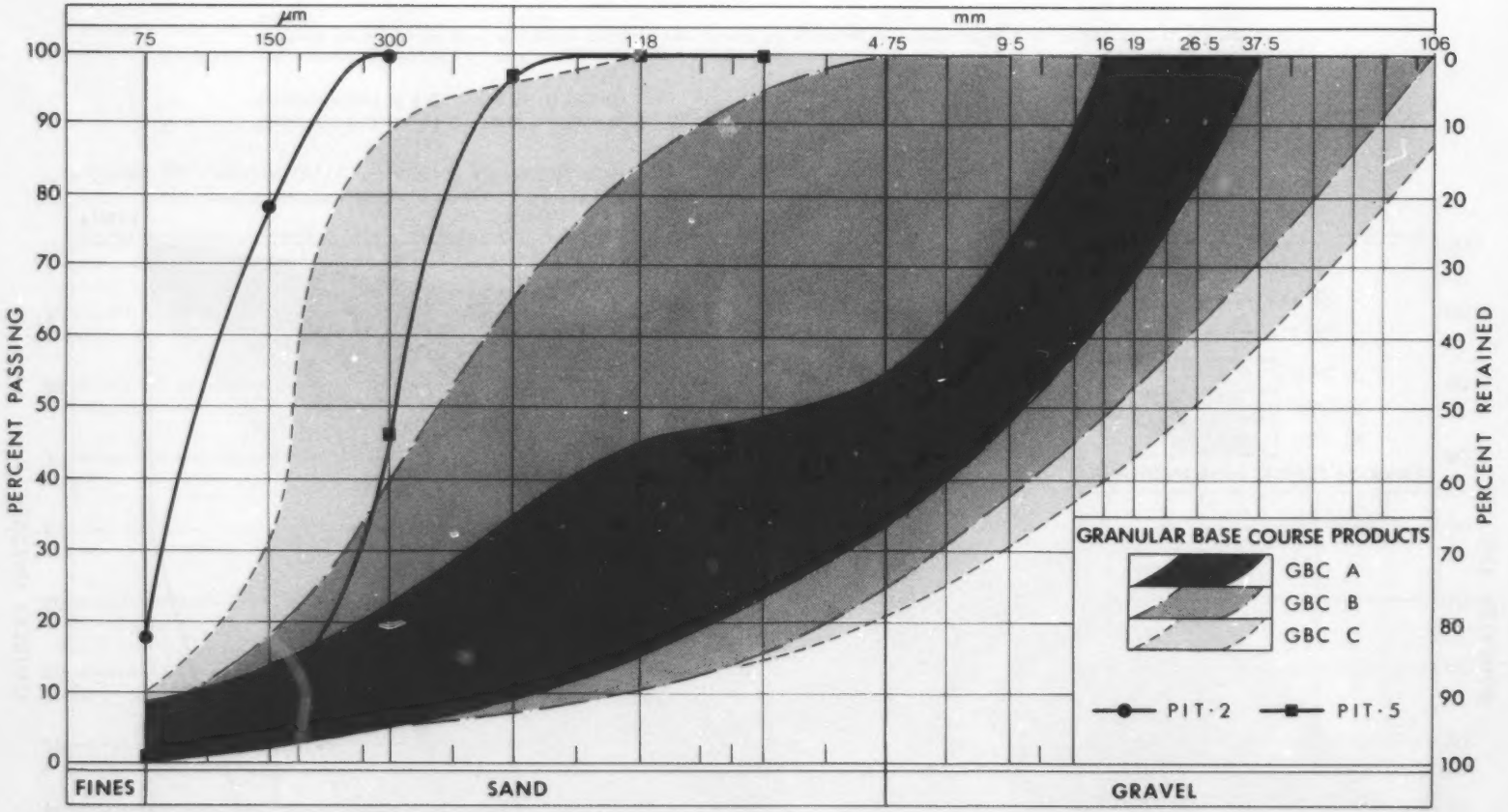


FIGURE 5b: AGGREGATE GRADING CURVES, FAUQUIER TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

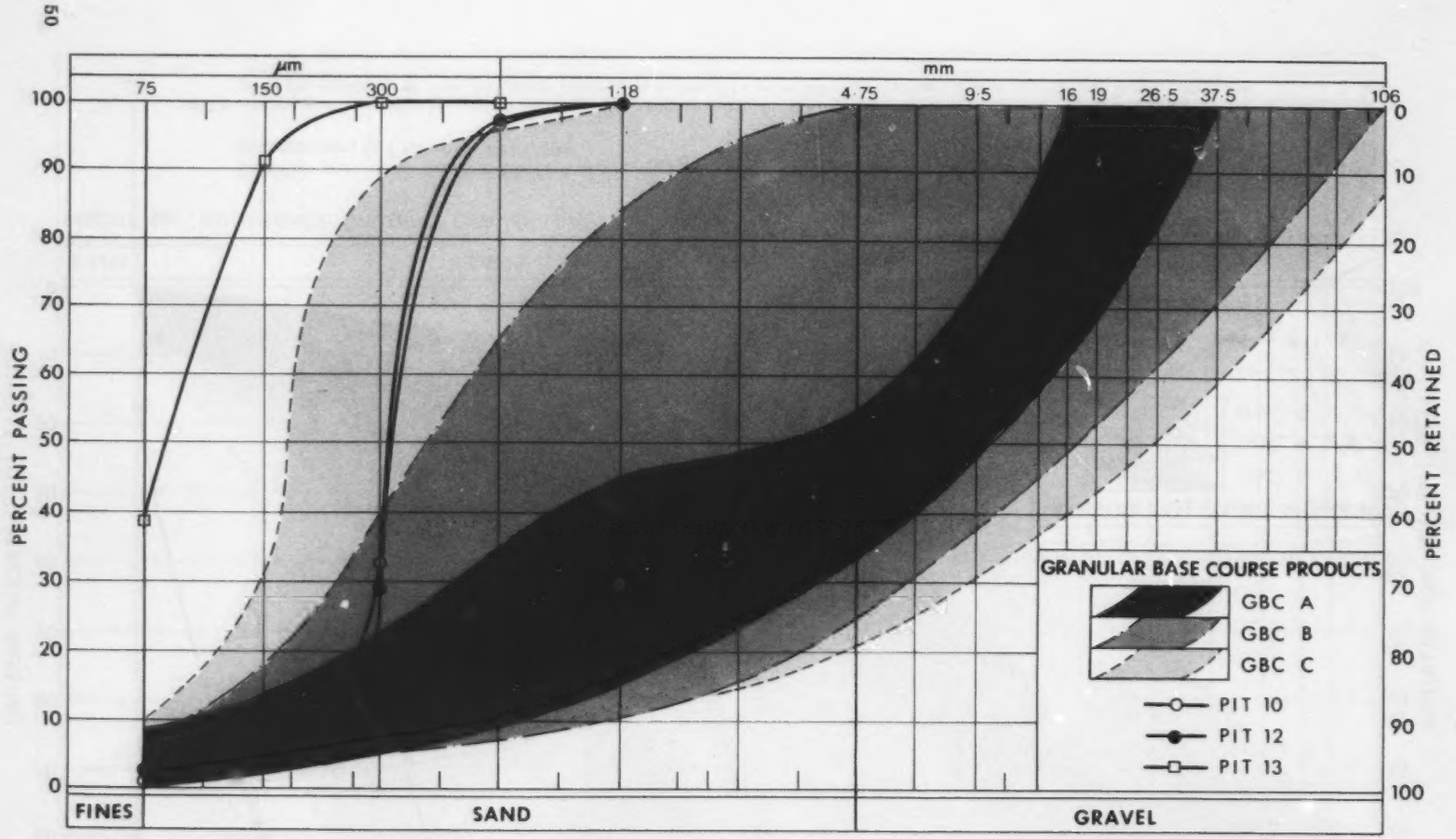


FIGURE 5c: AGGREGATE GRADING CURVES, FAUQUIER TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

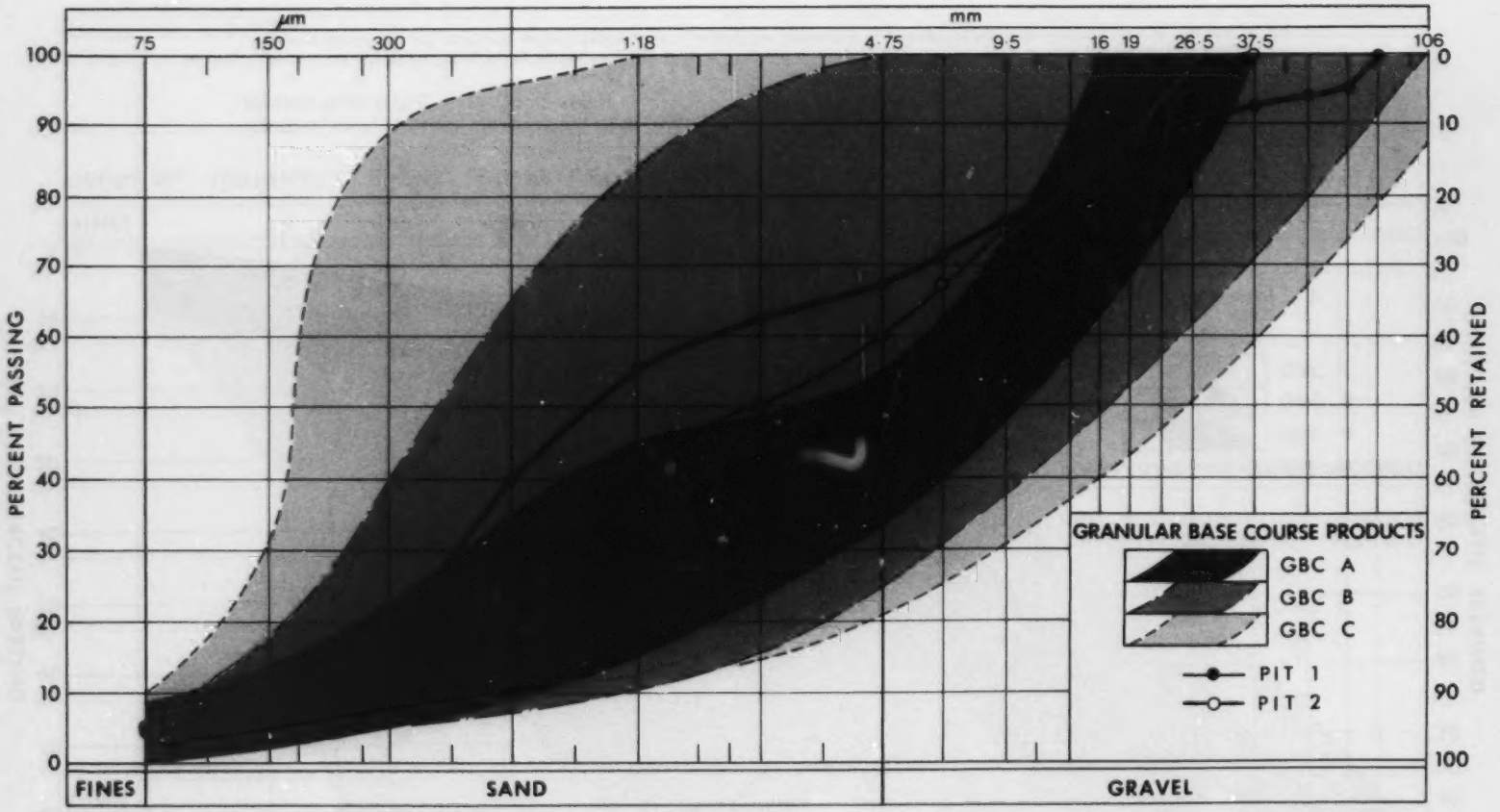


FIGURE 6a: AGGREGATE GRADING CURVES, OWENS TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

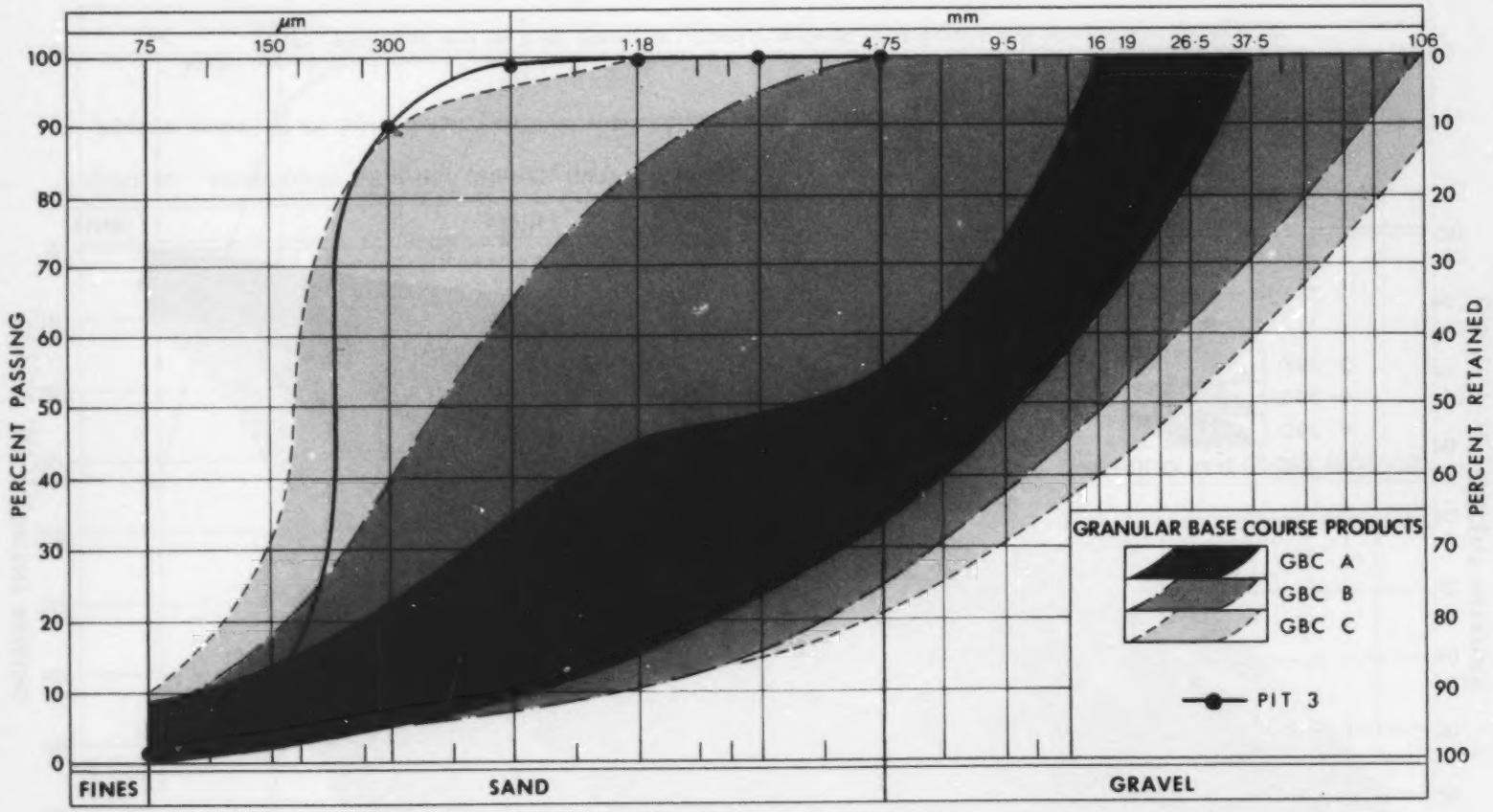


FIGURE 6b: AGGREGATE GRADING CURVES, OWENS TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

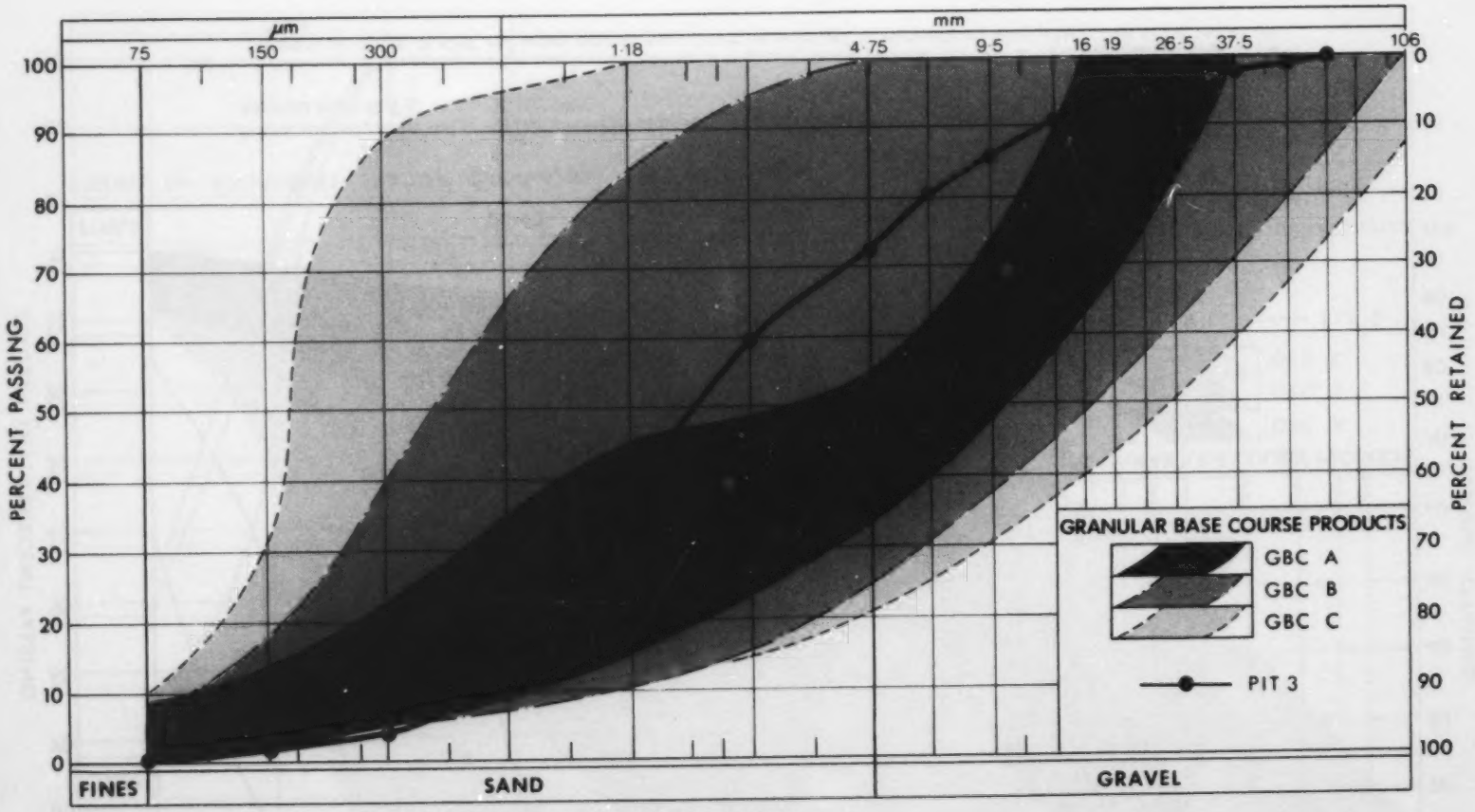


FIGURE 7a: AGGREGATE GRADING CURVES, WILLIAMSON TOWNSHIP;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

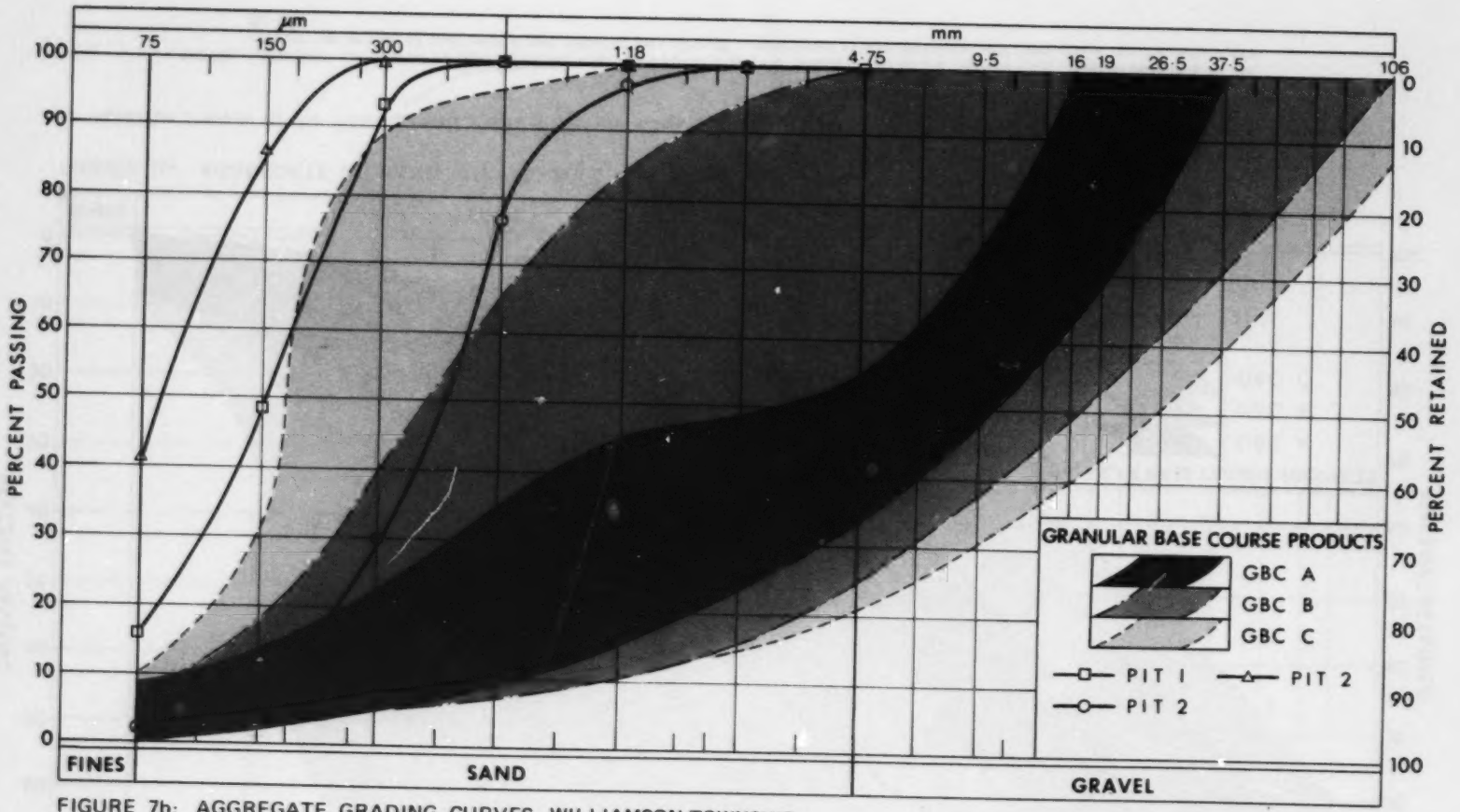


FIGURE 7b: AGGREGATE GRADING CURVES, WILLIAMSON TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

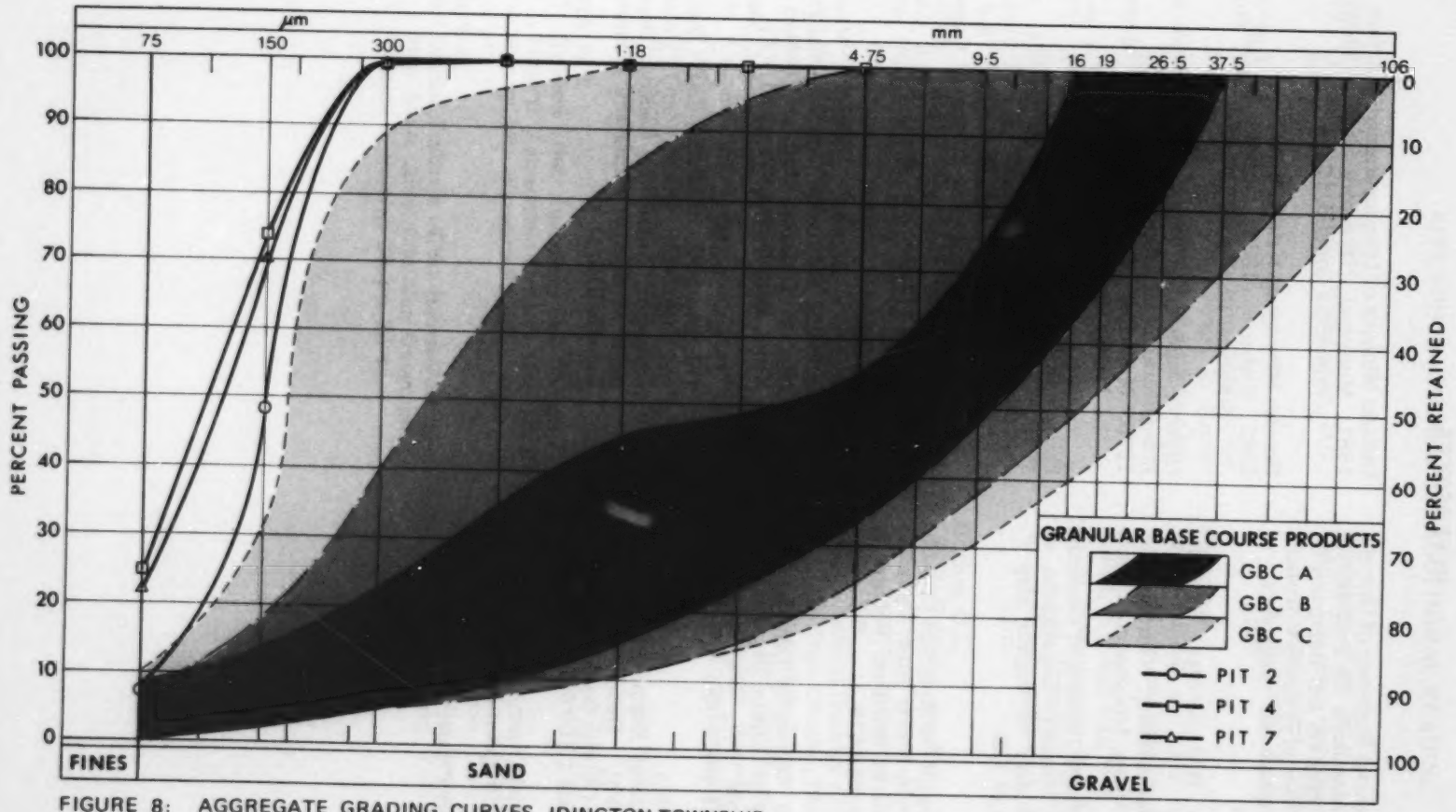


FIGURE 8: AGGREGATE GRADING CURVES, IDINGTON TOWNSHIP;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalis of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness, or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CLAST

An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone, and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions. Similarly, highly weathered, very porous and friable rock can restrict the quality of the aggregate.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (0.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GNEISS

A coarse-textured metamorphic rock with the minerals arranged in parallel streaks or bands, but lacking schistosity. Gneiss is relatively rich in feldspar. Other common minerals found in this rock include quartz, mica, amphibole and garnet.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulders	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANITE

Is a coarse-grained light coloured rock that ordinarily has an even texture and is composed of quartz, and feldspar with either mica, hornblende or both.

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability, and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3, and 4), or as binder course (H.L. 2, 6, and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition, and grain size. Generally, the description of the physical character of a rock.

MAGNESIUM SULPHATE SOUNDNESS TEST

This test is designed to simulate the action of freezing and thawing on aggregates. Those aggregates which are susceptible will usually break down and give high losses in this test.

MELTWATER CHANNEL

A drainage way, usually terraced, produced by water flowing away from a melting glacier margin.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of aggregate.

PLEISTOCENE

An epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Estimates of mineral aggregate material based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

PRECAMBRIAN

The earliest geologic period extending from the consolidation of the earth's crust to the beginning of the Cambrian.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt, or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone, and mudstone.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial stage of the Pleistocene Epoch in North America. It began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and they can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits, producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and

grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the glacier. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are no large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the underlying material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAIN (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. They commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN FORMS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments are almost

invariably composed of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D - GEOLOGY OF BEDROCK DEPOSITS
(After Bennett et al. 1967a)

ROCK TYPE A – FELSIC INTRUSIVE ROCKS

These rocks display a wide range in composition and texture. They range from granite to quartz monzonite to granodiorite, with textures varying from fine grained to pegmatitic, massive to foliated with schlieren or fragments of gneissic material. Graphic granite is very common in the area.

The felsic intrusive rocks occur as batholithic intrusions and related satellite stocks, as lit-par-lit injection layers in the gneiss complex, and as dikes and stringers in the gneisses, metasediments, and metavolcanics.

ROCK TYPE B – MIGMATITE-METASEDIMENTARY-METAVOLCANIC COMPLEX

These rocks exhibit a wide range of composition and metamorphic structure. Pre-existing metamorphosed rocks were deformed and recrystallized forming biotite and hornblende-quartz-feldspar-gneiss and granitic gneisses.

ROCK TYPE C – METASEDIMENTARY ROCKS

The predominant rock type is a fine-grained, massive to finely bedded, light to dark grey greywacke with greater than 80 percent quartz and feldspar. The remaining mineralization is made up of biotite, chlorite and sericite. Found with this rock type are fine-grained argillitic rocks, quartz layers, amphiboles and sandstone.

ROCK TYPE D – INTERMEDIATE TO MAFIC METAVOLCANICS

These rocks are fine- to medium-grained, light to dark green, massive to schistose rocks metamorphosed to amphibole, chlorite, or epidote-bearing greenstones.

ROCK TYPE E – DIABASE DIKES

These rocks are fine to coarse grained and gabbroic to diabasic textured.